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THE

AMERICAN

JOURNAL OF SCIENCE.

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THIRD SERIES.

VOL. XXXIII.—[WHOLE NUMBER, CXXXIII.]

No. 194—FEBRUARY, 1887.

WITH PLATES I TO IV.

NEW HAVEN, CONN.: J. D. & E. S. DANA.
1887.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 371 STATE STREET.

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THE

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[THIRD SERIES.]

ART. X.—*Kilauea after the Eruption of March*, 1886.* With Plates I and II.

I. *Communication to* Professor W. D. ALEXANDER, *Surveyor General of the Hawaian Islands, by* J. S. EMERSON, Assistant in the survey, dated Aug. 27, 1886: *On Observations in Kilauea made between March 24th and April 14th*, 1886. (With Plate I.)

. . . I reached the Volcano House soon after noon, March 24th (17½ days after the eruption) and remained three weeks, until April 14th. During much of this time the rain, drizzle and fog interfered materially with my work, but I had enough clear weather to accomplish most of what I had proposed to do.

With the kind assistance of the photographer, Mr. T. P. Severin, I measured a base line, 3532 feet in length, on the plain above the crater, near its northwest edge. With this base line I connected by triangulation the main points of my survey, filling in the details with a telemeter rod. Particular attention was paid to measuring vertical angles, from which I was enabled to compute the true height of every point located on the accompanying map, referred to the veranda floor of the Volcano house taken as datum. In addition to the information given on the map, I would add the following.

* For the communications here published, on the condition of Kilauea since the eruption of the 6th of last March, the editors are indebted to Professor Alexander. A brief account of the eruption is contained in vol. xxxi, p. 397 (May, 1886.)

During my stay no molten lava was anywhere visible in the entire crater. At certain points of easy access, a stick could be lighted by thrusting it down a crack so as to bring it in contact with the red hot rocks beneath. But in general there was scarcely a place from which I was prevented access on account of the heat. One of the hottest points visible at the time of my first descent into the crater, March 25th, is indicated on the map as *Severin's Furnace*, Mr. Severin having taken an excellent photograph of it. At that time, March 25th, its interior was still red with intense heat, but on my last visit to it, eighteen days later, it had so far cooled down as to excite no special interest on account of its heat. Another spot of considerable heat was a cone just to the southwest of my station at *Halema'uma'u S.* Surrounding it were a number of large cracks in the rocky floor of the crater, from which the hot air arose as from a furnace. By holding my breath as I repeatedly passed over them, I experienced no great discomfort.

Halema'uma'u.—On the 29th of March, in company with a tourist who had just happened along, and two native guides, from a point at the south side of Halema'uma'u, I descended into this pit, until then entered only by the Rev. E. P. Baker, of Hilo. The fragments of pahoehoe (smooth lava) over which I passed in my descent presented considerable uniformity as to size. In general they were irregular slabs, six, eight or more feet long, perhaps five or six feet wide and about a foot thick. I would remark that the greater portion of them occupied such a position that the slope of their surfaces nearly coincided with the general incline of the whole sunken floor of which they formed a part, though many were tilted up on one another in a most irregular fashion by the great fall occasioned by the removal of their liquid support on the 6th of March. I would also call attention to the fact that on this portion of the floor there was a marked absence of small fragments or gravel, which is to be contrasted with the condition of the sides of the deep central pit, soon to be described. Though our guides pointed out the danger and risk we ran of breaking a limb from the upsetting of any of these insecure slabs, we took our chances, and by carefully feeling our way with our walking sticks, passed safely down to a point near the edge of the great central pit. At the mouth of this pit the rough floor of pahoehoe slabs came abruptly to an end, leaving a nearly circular hole some 600 feet in diameter, looking almost as if punched out, from the brink of which the very regular sides sloped steeply down in the form of an inverted cone. The broken masses of pahoehoe that lay about the brink seemed to be so insecurely supported as to threaten suddenly to give way if disturbed, and precpitate themselves into the depths below. For

this reason I prudently refrained from trusting myself to their support, and did not approach near enough to the sides to examine the material of which they were composed. It presented a regular, lusterless surface, quite free from projecting rocks and also without notable fissures, and bore a strong resemblance to coarse gravel or small fragments of broken lava rock. At a depth, which I estimated at about 275 feet below the upper edge of this pit, was the very bottom of Halema'uma'u, an apparently smooth surface of black pahoehoe, entirely free from fallen rocks or debris, approximately in the shape of an equilateral triangle of about twenty-five feet on a side. It was not as level as the surface of a newly cooled lake. A portion rose somewhat irregularly above the rest and gave the impression of a mass of solid rock covered over with a thin coating of fresh pahoehoe. Near the northeasterly vertex was a small fissure from which arose a slender column of faint bluish smoke. The base of this smoke column afterwards served me as a convenient substitute for a flag in my triangulation, by which I accurately determined the depth of Halema'uma'u to be 900 feet below the datum at the Volcano house. I daily watched the smoke jet above described in hopes of seeing some marked change, but I was always disappointed.

The point of greatest interest to me was within the sunken area of Halema'uma'u, 750 feet northwest of the smoke jet in the central pit and 364 feet above its level. My attention was first particularly directed to it April 5th. While engaged in the survey of New Lake I noticed at that time a continuous jet of steam arising from this point. It had burst through the broken lava rock and had already made for itself an oval-shaped aperture, perhaps five or ten feet across. I thought I had seen it from the Volcano house for a day or two before, but had not made any special note of it. I now began to watch it carefully. The next morning, on observing it with a glass from the Volcano house, there was a marked change in its appearance, and I soon saw that it was no longer a jet of pure white steam, but of pale bluish, sulphurous smoke. The continued rainy weather prevented my visiting it again until April 8th, when I observed that the size of the aperture, as well as the volume of smoke had greatly increased. After another vexatious delay of several days owing to rainy weather,—wind from the northeast, regular trades,—I made my final visit to it on the 12th of April, when through the rift in the smoke, which was now pouring out from this elongated aperture, I saw the newly formed bank of glistening sulphur on the southwest side. As I was surveying in that vicinity I had occasion to occupy the station which I had already fixed at *Halema'uma'u W.*, on the edge of the precipice

overlooking the great abyss. My cautious native guide warned me that, as the station was directly to the leeward of the smoke jet, I would do well to avoid it, for fear of being suffocated by the sulphurous fumes. In spite of his warnings, I set up my instrument at this station and continued my work without regard to the smoke, which was blown by the wind directly toward me, passing a few feet over my head. I noted by my watch the length of my stay at this spot to be over thirty minutes. During that time the plumb bob of my instrument was considerably tarnished, but though at times I was obliged to stand aside for a moment to avoid the smoke, I suffered no special discomfort either then or afterward.

New Lake and Little Beggar.—On the 5th of April, followed by my native guide, I explored the abyss formerly occupied by the New Lake, and set up a flag at one of its lowest points marked on the map *Inferno*. Entering the $11\frac{94}{100}$ acre sunken district at a point near Central rock, I passed over a number of cracks in the inclined floor of pahoehoe from which arose a considerable volume of heated air, and paused for a moment at a still hot cone, now fallen in and rapidly cooling off. It had formerly been a most conspicuous object. To distinguish this small caldron of molten matter (once visible down its throat) from the great lakes of liquid rock, it had been dubbed the "Little Beggar." Passing over the old trail to Halema'uma'u I came to the edge of what had been called the "Bridge," between the two lakes. From this point the descent into the Little Beggar was quite abrupt, and the whole character of the rocky surface assumed a very different appearance. A large portion of the bottom of the lake was composed of huge, solid bowlders, as rounded and smoothed as if worn by some mountain torrent. They were covered about an inch in thickness with a fresh coating of black vitreous enamel, left adhering to them when the molten contents of the lake had sunk from view on the 6th of March. This enamel was very brittle, and, under the sharp blows of my walking stick, broke in pieces, exposing the solid rock beneath. The general appearance of the floor was that of a series of well-rounded hillocks and hollows, uniformly covered with the black coat already referred to. There was a marked absence of broken or angular fragments. At the base of the vertical wall, directly beneath New Lake 1, was a spot of considerable heat, much greater than that of any other place in the lake, (or what was the lake until the eruption). It was evidently the upper extremity of the shaft which had connected the boiliug lava in the lake with the depths beneath. The sides of the wall above it and the vertical faces of the massive rocks on its northwestern side formed an arc, somewhat circular, of perhaps ten feet radius. They showed the

peculiar glazed surface characteristic of all similar shafts in the volcanic districts of Hawaii. Its bottom, which I judged to be at about the level of the point marked *Inferno*, was closed with the fresh, shining black lava which had solidified as the retreating column had fallen to a lower level. Near the southwestern portion of the pit lay the huge hulk of the now stranded "Floating Island," a great mass of firmly cohering rock which, for more than four years previous to the sinking of the lake, had been floating like an iceberg and slowly changing its position on the molten flood. It now towered over sixty feet above its base on the bottom of the abyss and extended, I should judge, full a hundred feet in length. Piled against the southwestern base of the "Floating Island" was a mass of loose rock which had fallen from the sides above. Save at this point and at the end from which I had entered, the nearly vertical sides of the lake rose unbroken from the surface of the bottom to a height above the lowest point of 154 feet on the eastern side and 166 feet on the western side. These side walls, at least their lower portions, appeared to be of solid rock which had long been in direct contact with the intensely heated molten lava that until recently had filled the lake. The sides as well as the bottom were free from rents and cracks or any break by which the lava could have escaped. And they were everywhere coated with the black vitreous enamel which was a marked characteristic of the "New Lake." There was no direct lateral connection with Halema'uma'u to be seen. The evidence seems to point to the conclusion that the lava passed out of New Lake on the 6th of March by the same shaft at its bottom by which it had entered.

Very different was the condition of the treacherous sides of the abyss of Halema'uma'u. There, yawning fissures, with masses of rock just tottering to their fall, warned me to be very cautious in approaching the ragged edges of this still widening area of ruin. From time to time with a loud crash a portion of a cliff would fall a hundred and fifty feet or more, and dash itself to pieces on the sunken floor below, raising clouds of dust. It seems likely that this was what gave rise to the report that much smoke was rising from the lakes, for during the three weeks of my stay, there was no other smoke jet worthy of mention but the two already described.

Of steam jets in Kilauea the number was very variable, and seemed to depend greatly on the condition of the weather and the hour of the day. At times, especially in the morning, the whole crater was almost entirely free from them, while after a shower of rain, particularly in the afternoon, they were very numerous, and with the mist which often accompanied them, rendered the work of surveying impossible.

Outside of Kilauea, in addition to the large number of steam jets which are a prominent feature of the landscape about the Volcano house, there was a large rent in the earth crossing the road by which we came from Keauhou, extending in a southeasterly direction, at a point about two miles from the Volcano house. It was formed at the time of the sinking of the lakes, and when I observed it, on the 24th of March, the steam was still coming up from a considerable depth. A few days later, on a visit to "Kilauea Iki," a deep and apparently extinct crater to the east of the main crater of Kilauea, I crossed a similar rent, formed at the same time, nearer to the volcano, from which in like manner the steam was freely arising. I was also particularly interested in a line of steam jets, stretching away for miles to the southwest, arising from the steam cracks of 1868, the general direction of which, as observed by prismatic compass, was S. 44° W. On the 26th of April I examined a number of these steam jets, and found that in every case the sides about the orifice from which they arose were well covered with moss, proving that they were of an older date than the 6th of March. On the northwest side of, and running parallel with, the great steam cracks of 1868, were a number of smaller cracks in the extended plain of pumice. There were also a few on the southeast side. But in no case did I see any steam arising from them. The vertical section of some thirty feet or more in the sides of some of these fresh cracks furnished an excellent opportunity to study the arrangement of the successive layers of pumice, gravel, and fine sand which made up the mass of the great plains stretching for miles to the southwest of the crater. It was doubtless the ejecta of the volcano, which, blown thither by the wind, and accumulating for ages, must have attained considerable depth.

I was obliged to leave unsurveyed a portion of the sunken district to the southwest of the station, marked on the map *Halema'uma'u S.* It was an irregular district, of some ten acres extent, whose average subsidence I judged to be not over ten feet, save in that portion which, sloping rapidly down and connecting with the great abyss of Halema'uma'u, I found had fallen twenty feet and more. It lay nearly on the direct line from the central pit of Halema'uma'u to the steam cracks of 1868. On the 25th of March I remarked the great heat of portions of this district, and on the afternoon of the 12th of April, as I crossed it for the last time, I observed that while the crater had been decidedly cooling down as a whole, this portion had retained its heat in a marked degree, and was without doubt the hottest part of its entire area. The heated air still arose from it as from a furnace, and the steam jets from its fissures seemed unusually numerous and active.

Having now described the appearance of things as I had observed them, I will in conclusion call attention to some of the facts bearing on the cause of the great changes which had so lately taken place. On the east side of New Lake, some time ago, a small stone wall had been erected to shield those who wished to watch the lake at night from the wind and rain. The base of this wall I found to be 342 feet below the Volcano house. Mr. J. H. Maby, the manager of the Volcano house, very kindly gave me a statement of the height of the surface of the lava in the New Lake at various intervals from Dec. 1st, 1885, up to the 1st of March, 1886, as referred to the spot where this stone wall stood, and in his opinion the heights thus given would be true as well for the surface of the lava in Halema'uma'u, as there was no perceptible difference in the elevation of the molten surfaces of these two lakes. Though not claiming to be exact, these statements, coming as they do from an intelligent eye-witness thoroughly familiar with the locality, may be accepted as reliable. From them I am enabled to give the heights of the lava columns in these lakes at the various dates entered upon my map. From these figures it will be seen that the level of the lava in the lakes was rapidly rising during this time. During the fifteen days commencing Dec. 1st, 1885, it rose from 12 to 14 feet, an average of 0·87 feet per day. During the next sixteen days from Dec. 15th it rose from 18 to 21 feet, an average of 1·22 feet per day. On the 1st of January, 1886, it stood some 10 or 15 feet above the stone wall, and by the cooling and solidifying of its edges had raised the walls of the lake at that point a corresponding amount. Though the lake still continued to rise and build up its walls, it had found partial relief by a surface flow to the northeast, which eventually covered an extended tract of the desolate waste of pahoehoe which formed the floor of the crater. As it cooled it was difficult to distinguish the outline of this new flow from those which had preceded it. One of the points, which it reached a few days before it ceased, I have located by my *Pahoehoe* station on the accompanying map, from which it appears that it had flowed a mile and a half at an average grade of 1·77 feet per 100 feet. At the same time there was a smaller flow to the northwest. Halema'uma'u meantime was also overflowing and extending the rocky floor of the crater to the southeast and south, covering up the old beds of gravel in those directions. Apparently on account of the loss of matter by these flows, the rise of the lava column in the New Lake was from that time very much retarded. During the 59 days beginning with the 1st of January, 1886, it rose from 20 to 25 feet, an average of only 0·37 feet per day. On the 1st of March it stood from 30 to 40 feet above the stone wall, and at an

equal height above the level of the top of Houlder's monument, while the cone which it had formed, like a little mountain, towered to a considerably greater height. The weak sides of the crater could not long resist the immense pressure of such a liquid column. As long ago as 1868, they had been badly rent, and it needed but a slight disturbance to cause them now to give way and allow the liquid free exit. The coincidence of the collapse of the lakes, following so closely upon the solar eclipse of April 5th, suggests, as Mr. C. J. Lyons, of the Government Survey, has pointed out, the possible influence of the united pull of the sun, moon and Venus upon our planet as determining the time for the sides of the overstrained caldron to give way. Be that as it may, the time had come, and the whole column sank, within a few hours, a vertical distance of from 587 to 597 feet, disappearing in the depths below. Mr. Maby observed that the fire first went out in New Lake, some little time before its final disappearance from Halema'uma'u. This would naturally be the case from its comparatively shallow depth, as the molten mass was being drained away from the two lakes into the common reservoir or duct of exit beneath.

While a portion of the escaping lava may have taken a southeasterly course, indicated by the large fissure in that direction, already alluded to, a number of indications and considerations lead to the supposition that the greater part, following the line of least resistance, found its way into the great fissures of 1868, and, from the spongy nature of the district through which its course lay, readily found all the space needed to contain its entire volume without coming to the surface or entering the sea. It has been affirmed that the steam jets along the fissures of 1868 showed greater activity immediately after the subsidence of the lakes than at any time for months before. If this be true, it becomes an indication strongly favoring the above supposition.

The numerous cracks and fissures running parallel with the great steam cracks may then possibly be explained as follows: As the subterranean lava stream forced its way through these steam cracks, it would naturally compress and force upward the spongy mass on either side of their walls. But when the swollen stream had passed along and this pressure was removed, a portion of the inelastic mass would fall back to nearly its former position, while another portion, adjusting itself to its new position, would remain separated, and a new crack would thus be formed. The escaping steam, however, would find its natural outlet through the fissures most directly over its course, instead of seeking exit by any crack removed to one side of it. I have already remarked that this was

actually the case at the time of my visit. When we add to this the fact of the unsurveyed area of depression being in the line of these cracks, with the continued heat of portions of it and the number of steam jets there, the conclusion arrived at seems the more probable.

In closing, I would acknowledge my indebtedness to the Hon. S. G. Wilder for substantial courtesies extended to me during my long stay at the Volcano house; also the use I have made of the excellent map of Kilauea, made by William T. Brigham in the year 1865, from which I haye extensively copied, to show the relations of my survey to the general area of the crater.

II. *Observations of* L. L. VAN SLYKE, Professor of Chemistry and Natural Science and Government Chemistry, Honolulu, *on Kilauea, in July*, 1886.

I made my first visit to the volcano of Kilauea last July, a little over three months after Mr. J. S. Emerson's visit, and remained there from the 19th of July to the 24th. I descended twice into the crater, rainy weather preventing further observations that had been planned. The first trip down was made on July 21st, when I remained in the crater from 10 A. M. until 8 P. M.; my second visit, two days later, on July 23d, when I remained from 11 A. M. to 3 P. M.

Great changes had taken place in the pit of the crater, Halema'uma'u, since Mr. Emerson's visit. In the first place, a general upheaval had occurred in the center of Halema'uma'u; and, secondly, liquid lava had reappeared.

The steam cracks described by Mr. Emerson were in about the same condition in July as at the time of his visit. The places on the map marked "Furnace" and "Severin's Furnace" were very warm inside, but the heat was not great enough to prevent one from going within and remaining a few minutes. Only one red-hot crack was seen, and this was not far from "Central Rock," in the direction of "Halema'uma'u A."

Before speaking of the appearance and location of the places where molten lava could be seen, I will try to describe the appearance of the pit as I saw it and to indicate the changes that had occurred between April and July.

At "Halema'uma'u A," you are upon the brink of a precipice several hundred feet high, indicated by the black line on the map, extending around southward beyond "Halema'uma'u W" on one side, and eastward to "New Lake" on the other side. Just opposite this part, inside of the area bounded by this high precipice and nearly parallel to it, at a distance of perhaps from

400 to 1000 feet, there rises a very steep hill of loose rocks, perhaps 150 feet high, the base of which extends from the west wall in a rather direct line to the "Peninsula," or farther. Thus, between the wall around the pit and this hill of loose rocks, there is a deep trough-like depression. At the "Smoke Jet," near "Halema'uma'u W" the height of this hill of loose rocks suddenly drops to perhaps 30 feet, at which height the hill continues to the nearest point in the west wall. The "Smoke Jet" is located in the side of the hill just where the height drops down. This hill was found to extend on farther, being more or less clearly defined all the way around, so as to form really an immense cone with an oval or irregularly elongated base. This immense cone covers the site occupied by the deep central pit described by Mr. Emerson, as far as I can determine, —indicating that a general upheaval or rise of material had taken place in this part; for instead of a pit in the shape of an inverted cone there had appeared on its site an upright cone of lava rocks. The bottom of "New Lake" appeared to be covered with loose rocks. I did not explore this part at all carefully.

Molten lava was visible in three different places. Two of these were deep holes or wells, the other a "lake," covering perhaps five acres. I will describe these in the order in which I visited them.

Starting at a point between "Little Beggar" and "New Lake 1," I crossed the sunken "Bridge," and went, in nearly a straight line, toward the center of Halema'uma'u. For a little distance the route was down a moderate grade, but later it became very steep, when I came to the base of the cone of loose stones just described. The passage was over large slabs of pahoehoe such as Mr. Emerson describes. Ascending the cone part way, I came to the edge of a deep hole or well, of rather irregular outline, four-sided, perhaps 30 or 40 feet wide, and from 60 to 75 feet long, and not less than 100 feet deep. The mouth was surrounded by masses of loose rocks, rendering approach to the edge impossible or very dangerous, except at one point; from this point I could see the bottom of the well, and that it was covered with hardened fresh pahoehoe. At one side the liquid lava could be seen as it was puffed out of a small hole every few seconds and thrown up a few feet. The puffing noise accompanying the ejection of the lava was quite like that of a railway locomotive, though louder. The aperture through which the lava was thrown out might have been three feet long and two feet wide. Immediately beneath the point where I was standing, there seemed to be a constant and tremendous commotion, attended by a peculiar swashing noise, but I could not lean sufficiently far over with safety to see any-

thing. Fumes of sulphur dioxide were coming up in abundance, but being on the windward side I was not greatly annoyed by them.

Leaving this place, I went back some distance toward "New Lake," and then made a detour in the direction of "Halema'uma'u S.E." From near this point I went again toward the center of Halema'uma'u over a route, probably, quite near "Emerson's descent of March 29th." This led to a second well or deep hole where molten lava was visible. This well was nearly round, with a diameter of perhaps 20 or 30 feet, and a depth of about 100 feet. At one point the edge could be safely approached, but as it was on the leeward side, the fumes of sulphur dioxide could be endured only for a few seconds at a time. Like the other well, the sides were perpendicular. At the bottom was a cone having an opening at the top perhaps 10 feet across, and inside liquid lava was boiling with intense violence, every few seconds throwing up a jet of lava, the spray of which came to the mouth of the well, almost into my face. The drops of lava thrown to the mouth of the well had cooled enough to become hardened and black when they reached the level on which I was standing. This place was quite noisy, the noise resembling that of violently swashing waters.

Besides the deep holes just described, there was, as mentioned above, a "lake" of liquid lava. It was situated immediately beneath the west wall, or that of "Halema'uma'u W" It was in the bottom of the deep trough formed by the west wall and the cone-like hill of loose rocks. It extended from the "Smoke Jet" a distance of 400 feet approximately. The best point for observing it was near "Halema'uma'u A," although this was 1,200 feet distant or farther. It was too dangerous to attempt to get a view of the lake from "Halema'uma'u W" or any portion of the wall in that neighborhood, for the edge of the precipice was mostly of loose stones and a slight giving way of the embankment would precipitate one 150 feet below into the lake. It was possible to get down to the edge of the lake, but very hazardous. The lava first appeared just under "Halema'uma'u W" and extended south along the west wall a short distance. Gradually the lava overflowed until the lake was extended to "Smoke Jet," although this latter part was a few feet below the rest. From the fact that one part of the lake is elevated above the other, the lake has been spoken of as two lakes.

On the occasion of my first visit, I took my station at "Halema'uma'u A" about noon to watch the lake. When I first saw it, the entire surface was hardened and black, the only sign of volcanic activity being little steam jets here and there. After watching about an hour, I saw some liquid lava burst

through the black crust and flow a short distance, when it quickly became black and hard. These little outbreaks and flows of lava were taking place in various places on the surface of the lake during the whole afternoon. In the evening at 7:15 a very large outburst of lava came from the lake immediately below Halema'uma'u W, and, flowing in the direction of "Smoke Jet," overspread a large portion of the surface. After this the outflows were quite frequent and large during the next half hour. Little noise could be heard from our position. The "Smoke Jet" was pouring out large volumes of bluish smoke, depositing sulphur about the place of exit.

At the time of my second visit, two days later, I again took my position for watching the lake at Halema'uma'u A. There was evidently greater activity. The surface of the lake had been visibly raised by the constant outpouring and hardening of lava. At this time there was a great deal of noise, both of puffing and swashing. On the surface of the lake, at a point near the wall immediately below Halema'uma'u W, there was a place six or eight feet long and four or five feet broad, where the red-hot lava was in constant view, boiling over continuously and flowing away, and occasionally shooting up several feet into the air.

About the middle of July lava appeared in Halema'uma'u just beneath the wall at Halema'uma'u A. I saw the fresh pahoehoe at this particular place, but there was no further evidence of renewed activity at this point during my stay.

III.—*Report to Prof. W. D. Alexander, of* Mr. FRANK S. DODGE, Assistant Surveyor and Draughtsman, made Nov. 15, *on the Survey of Kilauea in the last week of September and the first of October*, 1886. With Plate II.

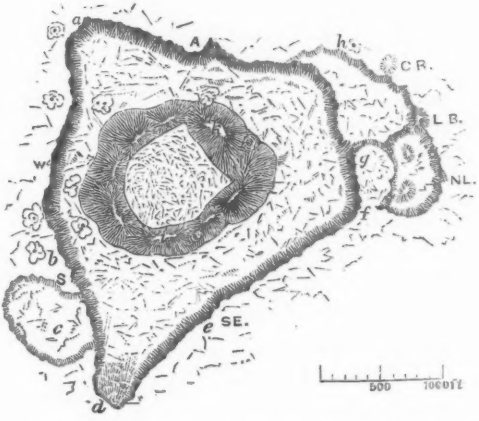
I herewith submit the following report of my visit to Kilauea, Hawaii, for the purpose of surveying the crater and vicinity, under the direction of the Bureau of Surveying. . . .

Leaving Hilo by the steamer Kinau, on the evening of Sept. 23d, '86, I landed at Keauhou early the following morning, and reached the Volcano House shortly before noon. The weather being favorable for surveying, a part of the afternoon was devoted to triangulation for the purpose of determining what changes had taken place since the last survey was made by Mr. J. S. Emerson, in March and April. From the triangulation I concluded that no material change had occurred in the general outline of the sunken district, covering the sites of Halema'uma'u and the so-called "New Lake."

At the very first opportunity I took careful observations to ascertain the height of two hills which had formed in the

Halema'uma'u pit, and later observations taken from the same station and under similar circumstances, showed that the hills were rising at the rate of nearly one foot per day. . . .

Having exhausted my supply of flags, I continued my walk along the eastern side, examining the ground carefully for proper locations for new stations, and visiting the very interesting small craters of Kilauea Iki and Keanakakoi. The former is about 3300 feet in length from east to west, and 2800 feet from north to south, with regularly sloping walls, completely covered with a dense growth of small Ohia trees, ferns, etc. In March last, at the time of the disturbance in Kilauea, a landslide occurred on the northeast side of Kilauea Iki, leaving the face of the cliff bare from top to bottom, and showing all the strata distinctly. The depth of this crater was found to be 749 feet from the point at the end of the path from the Volcano House, or 867 feet below the Volcano House veranda—which has been taken as a datum for all elevations connected with Kilauea.



Map of Halema'uma'u; from th map of Kilauea by Mr. Dodge, of which Plate II is a reduced copy. N. L., New Lake; L. B., Little Beggar; C. R., Central Rock. A, W, S, SE positions Halema'uma'u A, W, S, SE of text. Level below that of the datum mark at the Volcano House at *a*, 335·2; *b*, 350·4; *c*, 365; *d*, 344·5; *e*, 331·8; *f*, 337·4; *g*, 334; *h*, 321·3; *i*, 360; *k*, 329·5 (*i* and *k* on the cone).

Keanakakoi is 1600 feet in length and 1100 in width and approximately 400 feet in depth, with almost vertical walls, bare of vegetation, and a very smooth floor of pahoehoe.

From careful study of Mr. Emerson's map, and from observations made during five visits to the locality, I conclude that there has been no change in the "New Lake" depression, or in the "Bridge" between that and Halema'uma'u, and very little

change in the main walls of the larger pit. I think a small portion of the wall near the northeast corner has fallen in quite recently, covering a part of the new floor of pahoehoe with great masses of irregularly broken rock. As far as I was able to examine it, I could discover no other change in the outline. But since the survey of March–April, there have been great and important changes going on *in* the pit of Halemau'ma'u, the present scene of activity in Kilauea. The approximate center of the sunken tract is now occupied by an irregular pit or "lake"—surrounded by a range of hills, which were carefully located, but which prevented me from obtaining the exact size of the "lake." This range of hills, or ridge, is nearly circular in form (see preceding figure), and the distance from summit to summit across the pit from northeast to southwest is 1080 feet, from east to west 1100 feet and 930 feet from northwest to southeast. I was unable to learn the condition of the central pit from close personal observation, but from the flashes of light seen over it at night, I judged that there was some action, and the native guide, who had lately visited it, informed me that there was "plenty fire."

In various places on the sides of the encircling hills, or ridge, which are formed of fine, loose material and angular blocks of stone, there were many openings which emitted dense, bluish white smoke, and steam under considerable pressure. The mouths of the openings were coated with deposits of sulphur and many of them glowed with red heat at night. The space between the base of these hills and the foot of the pali or wall, on all sides, was being filled gradually by small flows of pahoehoe from vents all over the floor of the pit. Around the base of the hills and at various points near the pali, were many small cones and "blow-holes" which sent up quantities of smoke and steam. In the extreme eastern portion of the pit were immense blocks of lava piled up in confusion; and parts of the eastern wall that had fallen in at the time of the great collapse, but the remainder of the floor was nearly level and slowly rising.

Outside the walls of the pit, in the Kilauea crater, I found only three or four localities where there were signs of any great heat below the surface. The first of these was in a small crack a few hundred feet west of Central Rock, and not far from the edge of the cliff—where the rock was red hot within two feet of the surface, and I was told that it had been so for many months. At the eastern edge of the sunken area and directly north of New Lake were large openings to a tunnel that began near the "Little Beggar," and extended several hundred feet in a general northeast direction, and considerable heat was given out from cracks in its roof; and the same was the case in a small area directly south of the peninsula, between New Lake and Halema'uma'u.

At various points on the southeast half of Kilauea, and on the face of the cliffs in that section, small jets of steam were seen at times. The steam cracks near the Volcano House, and on the sandy plain north of the crater, seemed to be in their normal condition.

Almost the entire floor of Kilauea is formed of pahoehoe, that had flowed out from the region of the lakes late in 1885, or early in the present year, covering all traces of the old Black Ledge and other features shown on earlier maps. The slope of the pahoehoe floor is quite regular in every direction, the descent from Central Rock to the foot of Lookout Hill, where the trail strikes the pahoehoe, being 163 feet—135 feet to the base of Kaniakoha, 125 feet to the foot of Kamohoalii, 105 feet to the foot of Uwekahuna pali, 75 feet to the base of Pali Iki, and approximately 80 feet to the foot of the pali* on the southeast side. Near Uwekahuna is a large patch of *Aa* (surface made of large slabs or masses of rough lavas), a few acres in extent, which I think is the only lava of that nature in the crater.

In the southern end of the crater is a long point or spit of gravel and bowlders, extending from the southeast wall about four-fifths of a mile due west, bounded on the south side by an abrupt cliff, and sloping gradually to the north and west, until it is covered up by the pahoehoe flow of this year. This same flow has also encroached upon the south bluffs and covered the older formation at the head of the bay near Holoholokolea, so that at the extreme south angle in the bluffs, a further rise of forty feet, more or less, would cause Kilauea to outflow toward the sea. At the extreme southwest corner the pali has been entirely covered by the hills of pumice which form the southern boundary.

The summits of these low, rounded hills are about 1,000 feet back from the edge of the crater, and thence they slope gently to the south and southwest, and are traversed by numerous large cracks, extending in the latter direction. At the eastern end of the aforesaid gravel point are many deep cracks parallel to the general direction of the main wall of the crater on that side, and outside the walls are many more of the same nature.

I have attempted to describe the condition of the crater of Kilauea as I found it early in October; and from observations then made, I think that in the course of time, perhaps in a few months, the great central pit will fill up and overflow, as it did prior to the 6th of March, '86, and that the center of activity will continue to be in the present locality of Halema'uma'u.

* The word *pali* means a precipice.

Art. XI.—*Volcanic Action;* by James D. Dana.

The new facts with regard to the recent eruption and subsequent movements at Kilauea, make this a favorable time for a review of volcanic action and phenomena; and especially so because the Hawaian volcano and its great craters illustrate more fully and simply than any others that have been particularly described the ordinary principles and methods of volcanic activity; and also because, although long since reported on, they have not yet their true place in most treatises on volcanoes. Vesuvius has been more accessible. The account of the phenomena observed by me at Kilauea in 1841, given in my Exploring Expedition Report,* needs no modification. But the conclusions after so many years of progress in science may well have a reconsideration. On the chief point, however—the essential identity in forces and laws of action between Kilauea and Vesuvius as well as other volcanoes---I find no reason for change. In my Manual of Geology (1863) I present, as the causes of eruptions:

The hydrostatic pressure of the column of lava; the pressure of vapors escaping in underground regions from the lavas, or produced by contact with them, acting either quietly or catastrophically; and the pressure of the subsiding crust of the earth, forcing upward the lavas in the conduit. I also state as sources of movements preceding an eruption: the enlarging of the mass of liquid rock in its higher portions through the vaporizable material contained in it and imbibed on the ascent; and, for aerially projectile effects, the elastic force of the vapors that escape by the forming and bursting of bubbles at the surface of the viscid lavas.

In the following pages the sufficiency or not of these causes of activity for all volcanoes, is considered.

* Geology of the Wilkes Exploring Expedition of 1838–1842, published in 1849. 225 pages (4to) are devoted to the Hawaian and other volcanic islands of the Pacific, apart from the subject of the bordering coral reefs. The time of my visit to Hawaii and examination of the Kilauea crater was particularly opportune because of the great eruption that had so recently preceded it, and which left behind, besides features of more ordinary character, also those rarely presented. I find no facts in Capt. Dutton's report to lead me to modify my conclusions as to the mode of action in Kilauea, or as to the relations of the crater to those of other volcanoes. My tour to Kilauea commenced on the western shore at Kealakekua bay, and led me by the south side of the island and the southern slope, to Kilauea: and thence, after a study of the interior of the crater and its surroundings, eastward to the outflow of the great eruption of 1840 at Nanawale where it entered the sea.

1. *General.*

1. *The more prominent phenomena of volcanoes.*—In the upward movement of liquid lavas, two operations apparently distinct, are concerned: (1) the ascending movement of the liquid rock in the subterranean conduit of the volcano from the deep-seated crustal or sub-crustal region of fusion; (2) the projection of the lava aerially upward from the surface of liquid lava in the vent. Outflows accompany the upward movement whenever the height reached by the lavas is such that they have an outlet either over the walls of the crater or through an opened fissure. Each of these operations, the upthrow and outflow, involves an expulsion of material from subterranean regions; and a usual consequence (3) is a subsidence, or, *Anglicè*, a down-plunge, of the overlying rock, or the material of portions of the cone especially the more central. The upthrow, the outthrow, and the down-plunge are the three most universal and most marked of volcanic phenomena. Connected with these operations there are: (4) The escape of vapors from the crater, and (5) displacements and the opening of fissures.

2. *The ascensive action.*—The actual ascension of lavas to a height, in many volcanos, of more than 10,000 feet above the sea-level is evidence of (1) the great power of the agency concerned. In Mt. Loa, a volcanic mountain of frequent extensive summit eruptions, the height is 13,000 feet (or six miles reckoned to the sea-bottom on the east.) The observations of Mr. G. K. Gilbert on the laccoliths of the Henry mountains, proving that strata 10,000 feet thick were arched upward to a height of three to five thousand feet, by the ascending and *intrusive* lavas indicate that the ascensive force at work (2) is deep-seated as well as of great power. This inference is sustained also by the long continuance of the heat in the lava-conduit of many volcanoes, as shown by centuries of activity, in spite of the various cooling influences to which the upper part is subjected.

3. *The deep-seated ascensive action not catastrophic.*—Dr. Gilbert's valuable observations illustrate another point of much interest: the *slow* action of the force concerned, for catastrophic violence would have opened large fissures to the surface, and produced a surface discharge. A quiet mode of ascent is probably the common fact also in the larger fissure eruptions. The movement appears to be very slow in the supply conduit of a volcano. For the epochs of high level in the lavas of a crater —flood level, we might say—are separated by years, years being required for a rise in level of a few hundred feet. Three great eruptions in Kilauea were eight years apart, and, in the interval, the lift in each case was about 400 feet. The last of the three referred to occurred in 1840; and the eruptions which

have happened since illustrate the same fact. Similar testimony comes from other volcanoes. If the ascent in the upper part of the volcanic conduit is aided by some additional upthrust force, then the facts just stated make the deep-seated action by so much the slower, since in that case it is accountable only for a part of the whole rise required for an eruption.

4. *Superficial ascensive action.*—The deep-seated ascensive force in a lava-conduit should raise the contained liquid rock to a common level for all its places of discharge in a crater. It was to me a strange fact that the lava-pools over the bottom of Kilauea underwent independent changes of level—a sinking of a hundred feet or more in one, unaccompanied by a like change or any change in another. But this admits of explanation on the ground of occasional discharge by local fissures opened beneath, and on the ground of much friction along the local conduits, and a depth to the common junction as great perhaps as the space between the pools (half a mile or so in the great pit crater). It was more of a marvel that while the pools were in their usual state of ebullition, lavas should be lifted at times to a level 500 feet or more above them in a fissure intersecting the walls of the crater. Here was an effect of ascensive force, but of a force of relatively superficial origin. A similar fact is mentioned by Prof. Alexander in his notes on the summit crater Mokuaweoweo, cited on page 235 of volume xxxii (1886) of this Journal, where the lift was 800 feet above the bottom of the crater, and the eruption a large one. Some superficial agency must be concerned in such eruptions; and the same may occasion local oscillations in associated lava-vents.

5. *Surface action in the lava; Projectile effects.*—In an active volcanic vent the feeblest action possible is the quiet escape of vapors. The second stage is the aerial projection of lava in portions, masses, or fragments; which fragments may fall back as cooled cinders or as liquid lava, according to the height of projection. The latter stage may be the final one before the return to a feeble or an inactive state in the crater. But the third may follow, namely: the outflow. As long as the liquid lavas are exposed in the bottom of the crater, aerial ejections are possible and probable; and if sunk below the bottom, they may continue provided there are cavities large enough to admit of the action. This projectile force is evidently distinct in origin from the supplying force.

2. *Kilauea.*

6. *Character of the lavas of projectile ejections and of those flowing from the open vents.*—The lavas of projectile ejections when cooled are usually scoriaceous and often semi-glassy, and the

brittle material may be shattered in the projection, under friction and sudden cooling, into the finest dust; those of the streams flowing from the vents or pools are cellular and in part scoriaceous; over the bottom of Kilauea in 1841, they had a scoria-crust of 2 to 4 inches, easily separable from the stony part below. They were *froth-covered* streams. On the contrary, the melted rock escaping from fissures in non-volcanic regions, and those of the remoter fissures about a volcano, are generally stony, without a scoriaceous aspect in any part. Even over the bottom of Kilauea, lava that had come up through fissures distant from the lava-vents was of the more solid, stony kind "either solid stone throughout, or so excepting a *compact*, glassy exterior half an inch thick."*

The making of scoria is dependent on the kind of action characterizing the open lava vent—that is the aerially exposed extremity, or extremities, of a lava-conduit. In a fissure-ejection, some one or more places in the fissure may be broad enough to remain open as lava-vents with the usual phenomena.

7. *Abundant discharge of vapors of water.*—The exposed extremity of a lava conduit discharges vapors in great volume, the amount of which increases with the increase of activity. When at Kilauea in 1841, an immense column of heated vapors stood over the great lava lake Halema'uma'u (1,500×1,000 feet by Wilkes's measurement) and the southern half of the crater—its base some hundreds of feet above the lake, owing to the intensity of the radiated heat. It had the appearance of a threatening storm-cloud as Wilkes observes (iv, 225).† Yet this was six months after a great eruption. At times of extreme activity the pit is sometimes so densely filled with the vapors as to "obscure all the glowing fires."

Many facts show that the vapors are chiefly those of water, as is generally believed. The features of the clouds were those of ordinary clouds, and the shrubbery and ferns about the margin of the crater derived luxuriant growth from the condensed moisture.

No direct experiments were made; but we have from Mr. Emerson on page 90 of this volume, the statement that he was half an hour at his station near Halema'uma'u W exposed to the vapors that came with the wind from over the pit, and suffered nothing from the sulphurous fumes present; a fact showing that they constitute a very small part of the vapors.

While vapors are so freely discharged from the craters, the amount from fissure eruptions, even those in a volcanic region,

* My Expl. Exped. Report, p. 180. † Narrative Expl. Exped.

are generally small unless open active vents exist along such fissures.*

8. *Projectile action.*—In Kilauea, in 1841, the projectile action of the lava-pools, consisted in the throw of jets of lava to a height of 30 to 60 feet over the whole liquid surface—many rising and falling simultaneously. I watched the process for some time while within four or five feet of one of the smaller lakes, and, also, but necessarily from a much greater distance, the more brilliant display over the great lake of Halema'uma'u.

This lake, owing to contact with the air above had usually a red-hot surface (except when blackened at times in part by incipient cooling); but in the play of jets over its wide surface, lines of white heat, or very nearly white, opened to view between them, which a companion in the expedition, Dr. C. Pickering, well compared to a net-work of lightning flashes.

The jets were ordinarily 30 to 60 feet high; in one of the small pools about 30 feet, but 50 to 60 at intervals. At times of lull they ceased or nearly so. The diameter, if I remember rightly, was three to six inches. With a mean of 4 inches and a height of 30 feet, each would have contained about 400 pounds of lava, making the force expended equivalent to that required to raise 400 pounds 10 or 12 feet. They were in form, in rise and fall, and apparently in mode of projection, like the little jets over a surface of boiling water; and the word *ebullition* seemed to all appearance to express what was going on. On other occasions jets have been seen of 100 to 200 feet, and also of five or six feet and less. In the higher jets the lava is usually broken into parts, and the lowest of two or three feet are sometimes broad and hemispherical.

The boiling movement has been recognized by all who have visited the crater. Rev. Wm. Ellis, of Kilauea, in August, 1823, describes a lake as a flood of fire in "terrific ebullition;" and Capt. John Shepherd, R. N., there in 1839, speaks of the "violent ebullition" as "caused by the escape of elastic fluids which threw up the spray [jets] in many parts 30 to 40 feet."

In the case of "blow-holes" the boiling process goes on beneath a small aperture in the solid lavas, and the liquid rock is thrown up in masses or driblets, with swashing sounds, and volumes of vapor at each throw. Small, steep cones of lava are made around the hole; and one such, surmounted by a column consisting of adhering lava drops (each 4 to 5 inches across), the whole 40 feet high, is figured in my Report, and the

* Prof. J. Prestwich discusses the subject of the agency of water in volcanic action at much length in a valuable memoir read before the Royal Society, in 1886. He makes no use of the facts afforded by Kilauea or of the bearing of the phenomena there observed on the great subject of volcanic action. As the views here given on the agency of water, and the special methods of its action are those of 1849, I have no occasion to make further mention of Prof. Prestwich's paper.

figure has been copied into several text-books. The hole may be what is left of a small lava pool after contraction from cooling. It varies greatly in size, from that of the open lava-pool to a diminutive hole through which drops of lava only a fourth of an inch in diameter are thrown out. One of the specimens which I obtained at the crater was a group of three slender columns, two to three inches apart, and about seven inches high, each made of lava drops of the small size mentioned—a fourth of an inch. Often the blow-hole emits intermittently only steam, whose rush out sustains the appropriateness of the name. Prof. Van Slyke describes one in action and ejecting lava, on page 96, and Mr. Dodge speaks of others, emitting steam only, on page 100.

Rev. C. S. Stewart, at his second visit, in 1829, saw, as he states, four cones from a few feet to twenty in height projecting flames [lava-jet] under a "laborious action of steam," one of which, tapering almost to a point, had "been formed by successive slight overflowings of lavas which, as it rolled down, cooled into irregular flutings ornamented with rude drops and pendants"—a good example of blow-hole action and result.

9. *Source of the vapors.*—While part of the vapors, as is well understood, are from the same deep source as the lavas or from their constituents, and some water may be here included, far the larger part have a more superficial source. The vapors from the deep-seated source of a conduit should vary little in amount except through variation in the area of liquid rock exposed; and the same would be true if the lava were a fused sedimentary rock of the depths below. But in fact, the variation between a time of quiet and of approaching eruption is often immense; the amount may increase rapidly as the height of the lava in the vent increases, proving that, as usually conceded, other more superficial sources of water-vapor exist.

The more superficial source may be either, as is generally admitted, the sea, or the fresh water of the land. Marine products like chlorides abundantly deposited about steaming fissures in the crater and outside, as at Vesuvius, have been accepted by most writers as evidence of the access of marine waters; and the absence nearly of such products at Kilauea, I regarded as evidence of the access there of terrestrial waters mainly. The latter are as likely to be concerned as the former, and the more so in most volcanic regions on account of the distance from the sea.

The very abundant rains over eastern Hawaii, the bare cavernous lavas of the mountains, arranged partly in layers or streams, and partly in vertical dikes often radiate to the crater, and the freedom from water-courses over a large part of the eastern and southern slopes of Mt. Loa, led me to regard the

waters from rains as the chief supply; and Mr. Coan, who lived for years at the foot of Mt. Loa and watched the volcanic movements, was the first to suggest that seasons of abundant rain, besides multiplying steaming holes, increased activity and favored eruptions.

10. The introduction of outside waters, whether marine or fresh, into the lava conduit has often been thought an impossibility; and still it must be a fact, as this is the only means of getting the required water. The waters of the land, especially those of great rains, becoming subterranean, would descend deeply along the various vertical fissures, and the spaces by the sides of dikes, it may be to thousands of feet, since the bottom of Kilauea is between three and four thousand feet above the sea level, (and the summit of Mt. Loa over thirteen thousand); and if the copious waters filling the narrow passage ways below over a large area, anywhere reached the hot region along the conduit, they would encounter the action of the heat under great hydrostatic pressure, and be forced by the steam pressure generated into the conduit of ascending lavas as the easiest and only way of escape. Once within the conduit, they would follow the course of the hotter, more liquid, and upward-moving central portion, and expand into vapor toward the surface, there to make cellular and scoriaceous lavas, and escape as they could. The lavas from fissures that tapped the conduit below the level where the chief part of the waters were received should be feebly cellular, or not at all so; but froth-covered streams might be expected from the vents or pools of the crater; and cellular or scoriaceous from tapping near the top. The facts at Kilauea correspond precisely with this view of the operations, and give the explanation full support. The play of jets over the surface may serve to entangle some air and add to the volume of the confined vapors. But air alone has very feeble expanding power when heated, and could not make cells in the heavy liquid and much less make a scoria.*

11. *Projectile force at Kilauea.*—The vapors within the viscid lava struggling for escape are the obvious and the only possible source of the projectile results. The elastic force of the vapors would depend on the resistance to escape, and the resistance on the viscidity, as in the ordinary boiling process. The ascending spheres of vapors in the upper or more superficial part of the conduit would become bubbles at the surface; and the bubbles would continue to enlarge there until the elastic force within was sufficient to break the upper or weaker part, when a verti-

* The facts observed by Prof. J. W. Judd with regard to the waters present (sometimes over 8 per cent.) in an obsidian, (Geol Mag. for June, 1886), have interest here. See also the important paper by J. P. Iddings on Lithophysæ, at page 36 of this volume.

cal or nearly vertical projection of the materials of the broken bubble would follow. A partial cooling of the lavas tends to increase viscidity, and this may account for the higher jets. The mechanism exists in Kilauea for making cinder ejections; but in the case of so low jets—30 to 60 feet—the liquid material descends before it has had time to cool and the dropping masses that fall outside the lava pool plaster themselves to its sides. The only cinder cones are found on the slopes outside of the crater where greater viscidity, due to partial cooling, may have existed.*

Kilauea continues this easy, quiet throw of jets even in the covered chambers of the now-existing cone. Mr. Van Slyke speaks of the puffing up and throw of the lavas, and the swashing sounds. The work going on, producing these sounds and the throw, is the same as has been described—the breaking of bubbles of the viscid lava by the elastic vapors or gases within them.

12. *Fundamental forces at work in Kilauea.*—In review: the two chief sources of upward movements are (1) the slow-acting ascensive force carrying the lavas to the surface, where they become exposed to earth-surface agencies. (2) The elastic force of the vapors escaping in bubbles from the exposed surface of liquid lava, producing projectile effects; these vapors partly of ascensive origin, but chiefly from external waters that become subterranean and were forced into the conduit. In addition to the above: (3) Subterranean vapors in confined spaces (α) derived from the surface of the underground liquid lavas (those of the top of the conduit), or (β) made, gradually or catastrophically, from the approach or access of waters to the sides of the conduit, may, by pressure, produce:

(a) Disruptive effects, opening fissures within the crater and in the mountain's sides.

(b) Displacements or uplifts over large or small areas; and opening spaces for the intrusion of lavas.

(c) When acting on a surface of liquid lava, the thrusting of the lava into open spaces between layers and thus producing an elevation of the overlying bottom of the crater and of the sides of boiling lakes; or into fissures, and in the latter carrying the lavas to heights several hundred feet above the level of the active vents of a crater, as in cases above mentioned, just as mineral oil is often thrown to heights by the confined gases below.

(4) The hydrostatic pressure of the column of liquid lava in the crater is a common source, probably by itself, and cer-

* In former periods pumice-like cinder ejections took place from Kilauea or its vicinity; but they cover a wide surface south of the crater, instead of forming cones. See my Report, p. 183.

tainly in combined action with the preceding, of extensive fractures and outflows, and sometimes in the case of both the Mt. Loa summit crater and Kilauea, of large and lofty fountain-like throws of the extended lavas.

(5) The expansion of the moisture in the liquid lava into vapors as the lava approaches the surface, thereby expanding the lava in this upper part, making it cellular and raising the level of the surface. This effect is limited by the amount of moisture present, and by the degree of pressure that prevents moisture below from taking the form of vapor.

(6) Underminings, through the discharge of lavas, leading often to subsidences and engulfments, and chiefly of the central parts of the volcano about and within the crater.

In 1840, after a time of violent activity over the whole of Kilauea, the subsided area included a large part of the floor of the crater, it being nearly two miles long and about two-thirds of a mile in mean breadth, with the depth nearly 400 feet. It left the crater over the sunken floor nearly 1,000 feet deep and elsewhere over 600 feet.

In 1886, after more local activity the subsidence was mostly confined to Halema'uma'u and its vicinity (including New Lake) the area about half a mile square; the depth of the subsidence was small, the depressions that were left being due mainly to the escape of the lava and some sinking of the walls of the two pits. Owing to the overflowings and intrusions of lavas since 1840 without equivalent subsidences, the mean depth of Kilauea after this last eruption was about 400 feet. There may be great empty chambers beneath, and after a time of general activity and great discharge, another subsidence like that of 1840 in extent may occur.

The form of Kilauea and character of the operations now going on within it show that the activity (ebullition, etc.) was at some time in the past so general over the included area that the subsidences which followed the eruption affected the whole, nearly to the present outer walls; and that under such conditions Kilauea took its form and size.* The underminings that have since occurred have from time to time caused down-plunges of portions of the walls into the emptied spaces beneath and so increased somewhat its extent just as the walls of the pits in the crater emptied by an eruption continue to fall until the pits are filled again with lavas.

3. *Vesuvius and other Volcanoes.*

13. *Fundamental forces in Vesuvius and other Volcanoes.*—Vesuvius and the Hawaiian volcano differ much in externals, but not in forces, or in their mode of action.

* The plate in Ellis's Polynesian Researches represents the lower pit in 1823 (after a great eruption), as reaching at the time very nearly to the outer walls of Kilauea.

The *first* of the operations mentioned above is necessarily the same.

The *second* method of work and its consequences must also be the same; for vapors rise and escape from the crater in great abundance during periods of special activity, as attested to by many observers. For years the outside waters needed to afford the working steam gain access quietly; but at times there have been large incursions, as proved by the violence of the earthshakings, the vast amount and height of the cloud of vapors, and the lofty projection of cinders.

The recent eruption in the Tarawera Geyser district, New Zealand, affords an example in which only fresh waters were concerned, and one of much instruction. The Tarawera mountain, its height about 3,600 feet above the sea level, though made of volcanic rocks, had, previous to the eruption, as Mr. S. Percy Smith reports from observations in 1874, no distinct crater. On the morning of the 10th of last June, after some rumblings for an hour, the mountain (at 2.15 A. M.) was rent from north to south; three craters were seen to be in action; and soon after, as later observations have shown, there were seven craters in the course of $2\frac{1}{2}$ miles along the top of the fissured mountain, and other small craters on what was properly an extension of the fissure six miles to the southwest. Black clouds, lighted below by the fires, rose to a height of "10,000 to 12,000 feet," and red hot scoria and cinders were shot up a thousand feet or more. The rain fell with the falling cinders in torrents, accompanied with the thunderings and shifting winds of a tornado. By daylight the village of Wairoa, five miles distant, was covered a foot deep with mud, made from the ejected cinders or volcanic ashes, and the descending waters (rain).

Three days later, the action in the mountains had mostly dwindled to steaming fissures, and on going to the region, it was found that the fissure, which was over two hundred yards wide, passed through Lake Rotomahana, $1 \times \frac{1}{4}$ m. in area; that the lake had lost its water; that the bottom was 250 feet below its former level, and in it there was a line of mud craters and geysers, one of the craters throwing the mud to a height of 600 to 800 feet. Evidence of the work of ejection and engulfment in the mountain existed in the great size of the fissure opened, and also in the depth and size of the mountain craters, one of them 900 feet deep, another 600, with five others of less depth, besides a great sunken area, 2000 feet long, 600 wide, and 250 to 800 deep in the southwestern slope of the Tarawera mountain facing Lake Rotomahana. There can be no doubt here that in this great outbreak, so sudden, so abundant in cinder ejections (but no flow of lavas), the lost waters gained access to the fires under the mountain. The waters were in so great

abundance that they could not be driven back by the steam made at their approach to the fires; and they consequently entered,—the opened mountain having made upward escape for lavas and steam possible; and thence came the steam power for the grand occasion. And perhaps, the cooling action of so large a body of water may have put the surface-fires out, leaving the heat, however, in possession as before, at no great depth below.

Cinders are projected to a greater height at Vesuvius, and in most other volcanic regions, than at Kilauea; but this is proof simply of greater viscidity in the lavas; and the projected lavas fall in cooled masses or cinders because of the height of projection. Greater viscidity leads to the production of larger vapor-made bubbles before the explosion, and therefore fewer of them over a given surface of liquid lava; and, in times of moderate activity, the number may be only half a dozen or a single one at a time, while, on a like area, lavas with the Kilauea degree of viscidity would have scores. When at Naples, in May of 1834, there was at night an interval of seven to eight minutes between the explosions or the throw (some hundreds of feet in height) of fiery cinders; on the ascent, the following day, of four to five minutes; and on passing Stromboli, a fortnight later, June 16th, of fifteen to twenty minutes—the activity being less than usual, explosions every 2 or 3 minutes being common. As Spallanzani, Hofmann, and others have seen the rising bubble within Stromboli, the bursting, and, following this, the rush of vapor and the cinder projections, there is no reason to doubt that at Vesuvius, also, each throw of cinders has the same source. Mr. John Milne states that on his ascent of the Japan volcano, Oshima, in May, 1877, on approaching the top, successive explosions were heard every two seconds with occasional pauses, which explosions he found, on reaching the top, to be due to successive outbursts of steam, each projecting ashes and bombs to a height of nearly 6000 feet, that fell vertically unless wafted by the winds.*

At the eruption last June in New Zealand, above referred to, the "tremendous roar" of the craters that added to the terrors at Wairoa, five miles distant, was at Auckland, 120 miles away to the northwest, resolved into "a series of detonations, like the firing of a prolonged salute *at minute intervals*, with an occasional lull."† This fact signifies that only the heavier of the aerial vibrations reached that place. The roar heard at Wairoa was due to the simultaneous explosions in the several active craters and the storm and earthquakes; and

* Volcanoes of Japan, Trans. Seism. Soc. Japan, ix, part 2, 1886.

† Volcanic Eruption at Tarawera with an account of the Thermal Springs district of N. Zealand, by T. W. Leys.

the "minute" guns heard at Auckland were the larger explosions; and such a periodicity in the detonations, so rapid and continuous, shows that they were those of exploding vapor-made bubbles; for nothing else in the mechanism of a volcano can produce it.

The catastrophic effects of such an action, where the jets are single or few, are small, because the break of the vapor-enclosing shell takes place at the top, and the throw is nearly vertical; the energy is wasted in the throw of the fragments. Where many jets rise together in such lavas, as in a time of violent eruption, the explosive action is great; but it is still greatest at the center of activity, which is that of greatest liquidity and easiest movement. A cone of cinders about the vent might be destroyed by being added to the projections; but the more distant walls could suffer but little from the projectile action, except in the way of fissuring, and this might be all owing to subterranean shakings and the undermining; for the force from the accumulated elastic vapors in the rising and exploding bubbles is too much confined by the limits of the area of liquidity within the crater. Hence we have reason to doubt much that has been written about explosive eruptions projecting off the tops of mountains; or at least to question it, until the piles of great rocks from such projections have been described.*

The height of the aerial projections in some volcanoes is measured by thousands of feet; but how much of this height is owing to ascending currents of air is not stated. The fineness of the dust that goes to great heights makes it of easy transport.

14. The other forces acting at Kilauea, must be alike active in all volcanic regions. The third is the one usually appealed to by writers in their explanations of eruptions, especially 3*a*, 3*b*; and that numbered 3*c*, must have its effects also, although less easily detected where the crater is not broad and open, like Kilauea. The *fourth*, hydrostatic pressure, has, no doubt, far more common effects than has been recognized, especially in high-sloped mountains like Vesuvius. The quiet character of many of the fracturings at Vesuvius and of some of its large eruptions are strongly in favor of this conclusion. The sixth operation—subsidence or down-plunge of the undermined parts of the mountain—should be doubly more active at Vesuvius than at Kilauea, since the undermining in the latter is produced only by the outflow of lava, while at Vesuvius there is loss both by outflow and upthrow. I have alluded to

* According to some describers of the New Zealand eruption, the Tarawera mountain had its top blown off in the making of the great southwest chasm. The place affords an opportunity to ascertain whether the piles of masses of the solid rocks which in that case should exist, are to be found to the southwestward.

this point already in this Journal (xxxi, 396, 1886) and need not repeat here.

15. In external dress the crater of highly viscid lava is very unlike that of the feebly viscid. The cone in the former often rises with slopes of 30° to 35°; that in the latter, often of but 5° to 10°. The former commonly uses cinders largely in making its cone, or else has the less fusible orthoclase lavas to deal with; the latter is chiefly lava-made, cinder-deposits being subordinate to those of lava. The crater in one is lengthened upward at top by cinders; and has cinder cones about each vent of liquid lava within the crater; that in the other, is often a broad pit, with a floor of cooled lavas over which are large and small lava-vents, and low lava-made cones. The volcano of the former kind is more liable to catastrophic eruption with noisy earth-shocks, though often quiet in some discharges; those of the latter commonly work with comparative quiet, having their large outflows at times without announcements of any kind to those dwelling a few miles away. These are differences; but they are differences in some of the results of the action going on, not in causes or methods. The first of the two kinds of volcanoes prepares for a new eruption by the gradual filling of the emptied crater, doing this by means of one or more lava-vents in the bottom, which, besides throwing up cinders, have their little outflows (as well described by Scacchi for Vesuvius), and keep at the work until the crater is filled or nearly so; and then comes the break and the greater outflows. The second kind differ only as to the cinders; and in Kilauea, as to the height of the floor of the crater before the outbreak.

16. Both from Vesuvius and Kilauea we learn that, next to the lava-vent, the crater of a volcanic mountain is its prime or most fundamental element. It encloses the extremity of a lava-conduit of greater or less breadth that reaches down to the seat of fires; and this enclosure exists because of the ejections by outflows and upthrows and the consequent down-plunges, which superficial conditions in large part determine. The growing mountain-cone cannot be rid of its crater except by the gradual disappearance and healing over of the lava-vent; and commonly, when extinction happens, the crater is still of nearly full size. If half or wholly obliterated, it may be again restored; and is likely to be, if action is ever renewed in the region by new ascensive action below. If so renewed, it may go forward through refusions and new engulfments. But the first step may be the opening of the old fissure upon which the crater was originally made; in this way the lava conduit might secure for itself at once an open way to the surface.

It may be that the course of the old fissure has been a chief cause in determining the form of a crater; and it may lead, in

after history, to changes in the locus of the chief vent, or an elongation of the crater in one direction rather than another. The form of the Kilauea crater, and the existence of those steaming fissures southwest of it and others on the northeast side, suggest some such determining cause of change. The elongated form of Haleakala, the great crater at the summit of Eastern Maui, may have this explanation.

17. *Quiet after an Eruption.*—A decline to a season of quiet follows an eruption because the preceding action had opened fissures, and so the crater and the upper part of the conduit had become emptied of lava, and, as a consequence, had also become chilled down to the new surface. Further, in the inactive or weakened condition thus occasioned, the cooling of the conduit-lavas might sometimes extend to a great depth because of the still-continued intrusion of subterranean waters. The completeness of the quiet and the length of the interval would naturally vary with the greater or less extent of the discharge and of the accompanying cooling influences. An empty caldron will not overflow before its cracks are mended and the steam apparatus at work has again filled it; and it may be so badly cracked and the supply of heat so cut off as to fail of further use.

Art. XII.—*On the Coahuila Meteorites;* by Oliver Whipple Huntington. With Plate III.

In the October number of this Journal, appeared a description by William Earl Hidden of an assumed new meteorite discovered by Mr. C. C. Cusick, U. S. A., near Fort Duncan, Maverick County, Texas.

On reading the article referred to, the author was at once struck by the close resemblance of the iron described by Mr. Hidden to those described by J. Lawrence Smith under the head of Coahuila Irons; and supposed to belong to one fall, but found on the opposite side of the Rio Grande River from Maverick County. The Coahuila Irons referred to are—

1. Sta. Rosa Sancha Estate, found in 1850.*
2. Butcher Iron found in 1866.†
3. San Gregorio.‡
4. Chihuahua Hacienda de Conception.*

* This Journal, 1855, vol. xix, pp. 160–163.
† Id., vol. xlvii, pp. 383–385.
‡ Id., ii, 1871, pp. 335–338.

Mr. Hidden's reasons for thinking the Maverick County Iron does not belong to the Coahuila group are as follows (this Journal, October 1886, p. 306): "The Maverick County Meteorite was found more than one hundred miles in a due east direction from the famous Butcher Irons from Coahuila and that from the Sancha estate, Mexico, both described by Smith. But the density and composition of these last two irons show marked differences from that of Maverick County, Texas. 'The Sancha iron had a density of 7·81 and presented the figures of Widmanstätt similar to that of the Braunau iron,' (Smith). The smooth surface and regular form of this iron from Maverick County would also preclude its being a part of another fall, as it seems to be complete in itself."

That the Maverick County iron was found one hundred miles east of the Butcher iron, does not interfere with its belonging to the same fall; since the Santa Rosa and Butcher irons were eighty-five miles apart, the Butcher and San Gregorio about three hundred, and the San Gregorio and Conception about ninety miles apart. Moreover, J. Lawrence Smith writes (this Journal ii, 1871, pp. 335–338) that these were probably products of the fall of one meteoric mass, moving from the northeast to the southwest, the smaller fragments falling first. The meteorite described by Mr. Hidden is small in comparison with the others, and thus would naturally be found farther to the east.

The Santa Rosa iron weighed 252 lbs. The Butcher irons weighed respectively 290, 430, 438, 550, 580 and 654 lbs. The San Gregorio was calculated to weigh about five tons, and the Hacienda or Conception about 3·53 lbs. And then there is still a fifth mass said to be larger than any of the others.

Mr. Hidden states in his paper that the density and composition of the Santa Rosa and Butcher meteorites "show marked differences from that of the Maverick County, Texas;" but he mentions the density only of the first. It is worthy of note in this connection that the densities of the Santa Rosa and the Butcher irons differ from each other, according to Smith's determination, nearly as much as the Maverick County iron differs from the Butcher iron, and yet the two former are accepted as portions of one fall.

In order to see how far we can rely upon specific gravity for distinguishing these irons, ten determinations were made with different fragments of the same specimen of the Butcher iron, and these have been compared below with similar determinations of the other Coahuila irons.

Butcher.	Sta. Rosa.	San Gregorio.	Hacienda.
7·616	7·925	7·740	7·953
7·751	7·953	7·477	
7.836	7·826	7·555	
7·204	7·631	7·734	
7·758	7·632	7·487	
7·831			
7·867			
7·858			
7·405			
7.727			
Smith 7·692	7·810	7·84	
Maverick County	7·522		

Comparing Smith's analyses of Santa Rosa and the Butcher irons with the Maverick County as given by Hidden, it will be seen at once that, if Smith could conclude from the similarity in composition of the Santa Rosa and Butcher irons that they belonged to one fall, there appears no reason for considering that the Maverick County has a new composition, as it agrees more closely with the Coahuila analyses than they do with each other.

	Butcher.	Sta. Rosa.	Maverick Co.	
Iron	92·95	95·82		94·90
Nickel	6·62	3·18	By difference.	4·87
Cobalt	·48	·35		
Phosphorus	·02	·24		·23
	100·07	99·59		100·00

Furthermore, Mr. Hidden speaks of Smith's having compared the etched surface of the Coahuila iron with that of the Braunau. This comparison was made because the Braunau was the nearest iron at that time to compare it with, though differing widely from the Coahuila. Mr. Hidden's description of the etched surface of the Maverick County iron applies most perfectly to that of the Coahuila iron, particularly the appearance of two sets of fine parallel lines, which become obliterated by the continued action of the acid. That these lines crossed at angles of 70° and 110° of course means nothing when the surface was cut at random. (This Journal, Oct. 1886, p. 284–303.) The accompanying plate printed directly from a specimen of the Butcher iron will be seen to be wonderfully like fig. 3 in Mr. Hidden's paper, already referred to, and this appearance is utterly different from any other known iron.

Then he further speaks of the smooth surface and regular form of the Maverick County iron precluding its being part of the Coahuila fall; but his diagrams of the Maverick County iron might be taken for almost any one of the many Coahuila

specimens, each one of which, like the Maverick County, is complete in itself, and in Smith's description of the Sta. Rosa iron,* which is one of the most irregular of the group, he speaks of it as being "rather smooth with only here and there thin coatings of rust."

Still another point of resemblance is the softness of the iron, which, in the case of the Maverick County, Mr. Hidden says could be easily cut with a knife, while Smith states several times in his descriptions of the various Coahuila irons that they were soft, so that they could easily be cut with a saw.

With the attention which is now being given to the study of meteorites, and the numbers of new specimens which are coming daily into our cabinets, it is important that different names should not be given to different individuals of the same fall, as it confuses the science. A very marked incident of such a confusion of names is shown by the Sevier and Cocke County meteorites, which are of so striking a character that no one could possibly examine specimens of these two irons without unhesitatingly concluding that they were products of one and the same fall.

This meteorite must evidently have been a very large one, passing through West Virginia and the eastern counties of Kentucky and Tennessee, and it is probable that several masses fell during its flight, and were subsequently distributed quite widely, as described by Prof. C. U. Shepard, in this Journal, second series, vol. iv, p. 83. Fragments are constantly being offered for sale as specimens of silver ore, owing to the whiteness of the iron.

Through the kindness of Mr. George F. Kunz we were able to examine a specimen of the iron described by him in this Journal, third series, vol. xxxi, p. 145, which evidently belongs to the same fall.

Three years ago we received, through the kindness of Prof. N. S. Shaler, a specimen, said to have come from near Lebanon, Wilson County, Tennessee, with the same loose character and white color of the Sevier County iron, having also large nodules of graphite, and thin laminæ of very magnetic elastic foil, easily separable from the mass, so characteristic of that iron. This specimen we did not describe, because it so obviously belonged to the same fall.

Prof. Shaler further informs us that he has heard frequent reports of other specimens throughout that region.

* This Journal, 1855, vol. xix, pp. 160.

ART. XIII. — *A new Rhizostomatous Medusa from New England;* by J. WALTER FEWKES. With Plate IV.

A SMALL number of Acraspedote Medusæ have been taken in shallow waters along the shores of New England. The genera thus far recorded are *Aurelia*, *Cyanea*, *Dactylometra* and *Callinema*. Other genera are known to make their way or to be carried along in the Gulf Stream into our latitudes, and may sometimes be washed on our coast. Among these may be mentioned *Pelagia*, *Periphylla*, *Linerges* and others.* Some of these have already been taken on George's Bank and off Martha's Vineyard, but none have been recorded from the shallow waters along the coast line.

Through the kindness of Professor A. E. Verrill I am able to add to the above list of Medusæ found in shallow water near the coast, a fifth genus, a large Acraspedote jelly-fish, not only new to New England, but also one which is unlike any yet captured on the Atlantic coast of North America. This Medusa, the only non-tentaculated Acraspedote, so far as we now know, which ventures into our waters, is allied to a common species found on the western shores of Europe, *Pilema* (*Rhizostoma*, auth.) *octopus* Hæck., and to the *P. pulmo* of the Mediterranean Sea. It has no nearer relatives in the waters of the United States, so far as known, than the well-known *Cassiopea frondosa* and *Stomolophus Meleagris* Ag. of Florida, the Carolinas, and the Gulf Stream.

The single specimen of this new medusa from which my description and figure were made was captured in September, 1886, in New Haven harbor.† It was more or less mutilated when it came into my hands for examination, but owing to the exceptional toughness of the umbrella and oral arms, it was possible to study the more important organs and to write a description of them before the external form of the specimen had greatly changed.

* A list of Acraspeda found in the Gulf Stream by the U. S. Fish Com. Str. Albatross will be found elsewhere. There is no reason now known why any of these genera should not straggle at times into our southern bays and sounds.

† It was taken alive near the Yale Boat House at the mouth of the Quinnipiac River, near the extreme upper end of the harbor, where the water is somewhat brackish, perhaps four miles from Long Island Sound. It was caught by Mr. Arthur J. M. Andrus and preserved by Mr. George E. Verrill, during my absence from New Haven. When living, the diameter was about 18 inches. When first seen by me, after it had been in alcohol about a week, the oral cylinder and frills, and the radial tubes of the umbrella were of a rich deep brown; the distal oral filaments were whitish; the disk or "umbrella" was uniform translucent bluish white. My son told me that the color had changed but little from what it was in life. A. E. VERRILL.

NECTOPILEMA, gen. nov.

Nectopilema Verrilli, sp. nov.

Umbrella.—The form of the bell and the relation of the height to the diameter could not be made out from the broken fragments.* From what is known of certain related genera, it is supposed that the diameter is about double the height.† Exumbrella smooth. Gelatinous substance of the bell tough, thick at center, thinning out near the margin. There are eight sense organs, each of which lies in a broad deep incision in the bell-margin and is protected by a slightly developed hood. Each sense body probably lies in the radius of an oral arm.

The lappets of the bell-margin are of two kinds, known as the occular and velar marginal lappets. The velar lappets are divided into two kinds, those formed by shallow and those formed by deep marginal incisions. The eight pairs of lappets which lie one on each side of each marginal sense body will be known as the occular lappets. The velar lappets‡ with shallow incisions may be called the small velar lappets, and those with deep incisions, the large velar lappets.

The occular lappets are short, stumpy and rounded, projecting but slightly beyond the sense body, never extending to the periphery of the bell formed by the distal marginal tips of the velar lappets. The sense body has no marked conical pit or external "*Riechgrübchen*."

The smaller velar lappets are formed by a slight incision in the compound lappets, which lie on each side of the occular lappets. When taken together they are much broader than the so-called large lappets, and singly their breadth is not much less than the large velar lappets. The incision, however, which separates them from each other is less than that which separates them from the large velar lappets or the large velar lappets from each other. They are called the small velar lappets from the fact that the incision is so slight as compared with the incisions of the greater lappets. The compound base formed by the consolidation of two small lappets may be regarded as a single compound lappet. Each small velar lappet is triangular, pointed, thin, and flexible.

The large velar lappets are two in number between each

* The quadrant of the bell-margin represented in the figure is probably increased in size from the broken and therefore expanded condition.

† See *Crambessa Tagi* Hæck., Grenacher and Noll, Beiträge zur Anatomie und Systematik der Rhizostomeen, and *Pilema* (Rhizostoma, auct.) Hæckel, System der Acraspeden. In *Stomolophus* the relative height is more than one-half the diameter, and in *Lychnorhiza* it is less.

‡ The *velar lappets* are the marginal lappets between two pairs of *occular lappets*. An octant of the bell is therefore made up of two occular lappets, four small velar lappets and two large velar lappets.

pair of compound lappets* and are separated by incisions in the bell-margin equal to that in the radii of the sense bodies. Each large velar lappet is pointed at its free rim, thin and flexible. All velar lappets are penetrated by an anastomosing network of vessels, and are destitute of a marginal vessel skirting its rim. There are no tentacles.

Deep grooves in the exumbral walls of the bell, extending radially from the incisions, both occular and velar, are supposed to be in part characteristic of the live animal and in part due to the state of preservation. These are indicated by indistinct lines in our figure. They may be wholly a result of contraction of the bell margin.†

The distance between two sense bodies on the margin of the extended bell of a fragment is 105^{mm}. The thickness of the umbrella increase very greatly at the junction of the marginal lappets.

The lower surface of the umbrella (subumbrella) is divided into two regions, a central from which hangs the oral appendages and a peripheral. The peripheral region is occupied by sections of muscular fibers forming together a strong circular compound muscle. There are sixteen sectors in this compound muscle. The radii passing to the sense bodies and those to the incision which separates the two larger velar lappets of each octant of the bell-margin also indicate the line of separation of the compound muscle. Each sector of muscle is composed of a number of parallel folds extending from the radii mentioned and from a line near the union of the oral arms to a line connecting the occular and large median velar incision. The breadth‡ of the sector of muscle is 80^{mm}. In alcohol the muscle has a brown color; along the occular radii and that which passes through the large velar incision this color is absent.

The size and arrangement of these muscles recall that of the subumbral muscle of *Stomolophus*, and somewhat more distantly the same in *Crambessa Tagi*, as figured by Grenacher and Noll (*op. cit.* pl. iv, fig. vii, *m*), where, however, in the latter case the number of sectors appears greater. The prominence of the muscle on the under floor or subumbrella of *Nectopilema* is apparently very different from *Rhizostoma luteum* of the last mentioned authors, if pl. viii, fig. xvii (*op. cit.*), correctly represents the subumbrella of *R. luteum* Gren. and Noll.

* My nomenclature "*compound lappets*" will lead to no confusion if the reader remembers that two small lappets (*velar*) unite to form the compound axial region at the base of these lappets. The compound lappets adjoin the occular lappets (see figure).

† These furrows recall the radial furrows of the umbrella border of *Polyrhiza* Hæck.

‡ Distance from axial to abaxial border. Measurements of specimens of medusæ preserved in alcohol, are more or less deceptive.

Oral arms.—From the central region of the umbrella there hangs a complicated oral apparatus known as the Mundscheibe. The general form of this region is pyramidal or more like the frustrum of a cone.

The oral region of the medusa consists of a consolidated portion, oral cylinder, next the subumbrella, by which it is joined to the bell, and a more distal part composed of eight separate oral arms. It was impossible for me to study the structure of the basal region, or oral cylinder of the Mundscheibe for the reason that it was broken from its attachment so that the union could not be observed. At the same time it was for the same reason impossible for me to observe the character of the genital cavities and the central gastral cavity, structures which present most important characters in the study of the *Rhizostomidæ*. The wall in the region of the mouth opening was also ruptured so that it was impossible for me to observe whether it really exists. Portions of the genital glands were found clinging to the basal region of the Mundscheibe, but their true form and relation to other organs could not be determined. The distal region of the mouth-apparatus is the best preserved of all the fragments which were studied. These are markedly peculiar and different from the same structures in other medusæ which have been figured.

Two different sets of appendages to the oral cylinder make up the distal extremities of the oral apparatus. The longest of these, eight in number, are direct continuations of the oral cylinder, and will be known as the oral arms. The second set of appendages are shorter than the former and are sixteen in number. These will be described as the scapulettes. The oral arms are gelatinous, more or less angular appendages, arising from small supports, and gradually broadening and enlarging towards their free distal ends. Near their free extremity they subdivide in fleshy, gelatinous lobes, along the edges of which are sucker-like structures, which will be described as sucker-frills. The outer or abaxial region of the oral arms is smooth, rounded, angular, the gelatinous wall being rather thick. On the axial side the gelatinous substance of the oral arms thins out, and along the margin the lobes bear sucker-frills. Each oral arm is generally irregular, trifid, and in some cases we find a large number of gelatinous lobes at the distal end of the arm. When the arm has three lobes, two of these lobes were observed pointing abaxially and one axially. Along the free edges of these lobes there extends a thin, membranous structure with small papillæ or pigmented projections. These membranous folds are mouths, and from their form are called the sucker-frills. Those frills on the two outer lobes are known as dorsal frills; those on the axial, the ventral frills.

The ventral frills extend along the axial edge of each of the oral arms to the junction of the oral cylinder, while the dorsal are simply turned outward and do not extend along the outer sides of the arms, which are smooth and destitute of appendages. In addition to the three lobes mentioned—two dorsal and one ventral—there are others also bearing sucker-frills, so that in some instances it is impossible to recognize three separate lobes.

The lobes bear terminally long, gelatinous, filamentary appendages called "*Kolbenförmige Gallertknöpfe*. These bodies, always gelatinous and colorless in alcohol, are of varying sizes and lengths, sometimes slender, often inflated, short, band-shaped. These appendages are numerous.* The smaller appendages to the oral cylinder are sixteen in number and are known as the scapulettes† or upper leaf-like appendages. They arise one on each side of the base of the oral arms a short distance above the separation, and hang down parallel with the oral arms. Two surfaces may be distinguished in each scapulette—an abaxial convex, and an axial concave side. The concave side is smooth, gelatinous, thick, rounded or angular. The convex side is more irregular, and lobed, skirted by sucker-frills resembling those of the ventral lobes and the axial side of the oral arms. The color of the sucker-frills of the scapulettes in alcohol recalls that of the sucker-frills of the oral lobes.

The relative position of the scapulettes as compared with the oral arms may be seen in my figure. Whether, however, these bodies are hidden by the margin of the umbrella when in contraction cannot now be determined. The reader is reminded that in my specimen the oral cylinder is broken from the bell, and so far as this goes, our figure is a restoration intended to show the bell-margin and the scapulettes, not the relation of one to the other.

Affinities.—Nectopilema is thought to be a member of the family of Acraspeda called by Hæckel the *Pilemidæ*. The family *Pilemidæ* Hæck. includes Rhizostomatous Acraspeda with four separate subgenital cavities,‡ and with dorsal as well as ventral sucker-frills on the eight mouth-arms. No tentacles and no central mouth opening, and numerous sucking-frills extending along the oral arms perform the functions of the

* The number and character of these appendages recall what has been described in a *Rhopilema* from the China Sea. They resemble the "*Peitschen Filamenten*" of *Polyrhiza* and others.

† This term here used to designate these bodies is the modified "*Scapuletten*" of Hæckel's description. It seems to me a better designation for these bodies than the term "leaflike appendages" sometimes used in descriptions.

‡ From the mutliated condition of my specimen the structure of the genital cavities could not be made out.

mouth. Eight sense bodies on the bell-margin. Eight to sixteen or more narrow radial canals, branched, and forming by anastomosis a network of vessels in the subumbrella. Generally with a ring canal.* Four internemral sexual glands in the aboral wall of the four separate gastral subgenital cavities.

The *Pilemidæ* are divided into three sub-families; I. The LYCHNORHIZIDÆ. II. The EUPILEMIDÆ. III. The STOMOLOPHIDÆ.

The *Lychnorhizidæ*, among other characteristic features, differ from the other sub-families in the absence of scapulettes.

The *Eupilemidæ* and *Stomolophidæ* have eight pairs of scapulettes, but in the former sub-family the eight oral arms are three-winged,† free from each other, and not grown together. In the *Stomolophidæ* the oral arms are dichotomously branched, and more or less grown together. *Nectopilema* is thought to belong to the sub-family of *Eupilemidæ*, and to be allied to *Pilema* and *Rhopilema*. The presence of "Scapuletten" removes it from the *Lychnorhizidæ*, *Toreumidæ*, and *Crambessidæ* as defined by Hæckel. It differs from the *Stomolophidæ* Hæck. in that the oral arms are not consolidated as in *Stomolophus*, nor dichotomously branched at their free extremities as in *Brachiolophus*, the only two genera of this sub-family. It is more closely allied to *Brachiolophus* than to *Stomolophus*.

The close allies of *Nectopilema* among the *Eupilemidæ* are the two genera *Pilema* and *Rhopilema*. From the former it differs in several particulars, the most striking of which is the possession of numerous "Gallertknöpfe" appended to the lobes of the oral arms. Whether this feature is enough to separate *Rhopilema* from *Pilema* cannot be discussed here. It is noteworthy that Hæckel found a specimen of the common *P. octopus* (*Rhizostoma octopus* auct.), regarded by him as abnormal, in which there were numerous appendages to the oral arms, as in *Rhopilema*.

Of the different species of *Pilema* all except *P. clavigera* Hæck. have a larger number of marginal lappets in the umbrella margin than *Nectopilema*, which has forty-eight velar lappets (six in each octant) and sixteen occular, while *P. clavigera* has thirty-two velar and sixteen occular lappets. *Nectopilema* has numerous filamentous appendages to the oral arms, while, as far as known, *P. clavigera* Hæck. has but one.

* *Nectopilema* has no marginal ring canal.

† Both the Lychnorhizidæ and the Eupilemidæ, according to Hæckel, have the eight oral arms "*dreikantig*" or "*dreiflügelig*," while the Stomolophidæ have oral arms dichotomously branched, more or less grown together. The lobes of *Nectopilema* are more than three to each oral arm, but the arms are not branched nor grown together. This fact adds a new argument to support my supposition that *Nectopilema* stands on the border line between *Brachiolophus*, *Pilema*, and *Rhopilema*.

Rhopilema has sixteen small velar and two occular lappets in each octant, which is thought to be a sufficiently marked difference to separate it from *Nectopilema*, which has six velar and two marginal lappets in each octant.* Moreover, Grenacher and Noll's figure of *Rhizostoma luteum* Gren. & Noll, to which, according to Hæckel, *P. clavigera* is related, differs from that of my *Nectopilema* so widely that I cannot think that my genus is the same as his *P. clavigera*.

There remains to be mentioned the relationship of *Nectopilema* to the genus *Polyrhiza*, a genus belonging, according to Hæckel, not to the *Pilemidæ* but to the *Toreumidæ*. Of all the *Toreumidæ*, *Polyrhiza* is the most closely allied to the *Pilemidæ* and to the sub-family *Stomolophidæ*. It certainly is not known, so well as might be wished, what is the structure of certain organs of *Polyrhiza*, nor what its true affinities are. Hæckel has placed it in the family of *Toreumidæ*, while *Brachiolophus* and *Rhopilema* are placed with the *Pilemidæ*. There are resemblances between *Rhopilema*† and *Polyrhiza* which imply their close relationship. As *Nectopilema* has strong resemblances to *Rhopilema*, it also has affinities with *Polyrhiza* Ag. I cannot, however, place it in this genus as at present defined.

The following characters when combined are thought to distinguish *Nectopilema* from other *Pilemidæ:* Six velar lappets in each octant; no tentacles; sixteen scapulettes; eight oral arms with numerous gelatinous filiform appendages, "*Gallertknöpfe.*" The genus is believed to belong to the Pilemidæ, connecting the Stomolophidæ and the Eupilemidæ.

Exlpanation of the Plate.

This Plate represents a side view of *Nectopilema*, showing the oral arms and a portion (quadrant) of the umbrella margin. As the bell was in fragments it was not possible to give its form, and therefore the relative extension of the oral appendages beyond the bell-margin may not be accurately represented.

In the medial line on the bell-margin a sense body is represented. On either side we have octants of the bell-margin with occular and velar lappets.

The bodies seen behind the bell-margin are sexual bodies. Their extension is more or less conjectural, as they were more or less ruptured. The leaf-like appendages to the sides of the oral apparatus below the bell-margin are the scapulettes. The lower part of the oral appendages or oral arms bear filamentous appendages or "*Kolbenförmige Gallertknöpfe.*"

The figure was drawn from nature by Mr J. Henry Blake. It is one-half natural size of the alcoholic specimen.

* The marginal lappets correspond closely with those of *Cramborhiza flagellata* or *macronema* (both specific names given by Hæckel in the same work, *op. cit.*). This genus (Cramborhiza), according to Hæckel, is allied to Lychnorhiza, which has no scapulettes.

† It is probable that the numerous "*Kolbenförmige Gallertknöpfe*" of *Rhopilema* and the "*Peitschen Filamenten*" of *Polyrhiza* are homologous.

Cambridge, Mass., Dec., 1886.

Art. XIV.—*A short Study upon the Atmosphere of β Lyræ;* by Orray T. Sherman.

A comparison of the observations upon the spectra of those stars admitted to possess a spectrum comprising bright lines leads to the conclusion that, while persistent in place, the bright line is not persistent in intensity. That this is the case in the solar chromosphere, β Lyræ, γ Cassiopeiæ, R. Geminorum, γ and η Argus, the Wolf and Rayet stars, and through the courtesy of Dr. Konkoly we add η Ceti, may not be doubted. In the others also it seems probable. This peculiarity, now presented as a characteristic of the bright line in stellar spectra, affords a distinction between bright line light, bright background space, and any accidental disturbance the spectrum light may suffer.

Under its guidance the observation was extended to noting the relative places of every persistent or at times outflashing break in the spectrum light, and the single observation was replaced by a series as frequently as opportunity allowed. For greater intensity of bright line light, the sharply focussed star was made to replace the slit, the jaws being symmetrically opened, so that, while allowing the full disc to pass, any displacement soon caused a diminution of the stellar light. For reference spectra the jaws were reclosed. The cylindrical lens was removed. The observing telescope was of low power. For least intensity of background light, the highest dispersions practicable were employed. No foreign light was permitted, the telescope being set during the day so as to be swept upon the star. The record was automatically made. The routine of observation is as follows: For some time previous the observer's eye is kept in the dark. Seated at his telescope, he has then before him a faint, barely traceable line of light, beading or imbedded in which are a number of bright monochromatic stellar images. These points are brought so as to be bisected by the edge of the thick cross-bar which it is desirable to employ. The position is recorded and the observer proceeds to the next dot. In this way he has usually passed through the first, second and a portion of the third spectrum. At the end of the observation the position of the bright lines afforded by a salted alcohol flame or Plücker's tube are added. The slip is withdrawn. The relative position of the punctures are measured and the wave-length reduced by a proper formula. The record of the three spectra combined in one is then recorded as the result of the day's observation. The spectra in which the especial line has been observed forms a measure of its intensity. In combining one day's work with the others, those lines which lay nearest together have been referred to

the same line. No line has been admitted unless circumstances rendered its admission necessary. The mean of each horizontal line has then been taken as the approximate wave-length. Throughout the observation the observer has absolutely no definite knowledge of the identity of any especial dot. Nor is it possible for him, while at the telescope, to connect one day's work with another. Nor in tabulating is there any great chance for judgment.

These appearances seem worthy to be classed as bright lines, for (1) they are seen as well with prism as with grating; (2) their number increases as the dispersion increases; (3) they occur for periods together, and are absent for periods together; (4) they remain constant in position but vary in intensity; at times they are dazzling bright, and at times they are faded, scarcely noticeable; at times they remain a steady glare, at other times they sparkle in and out, are caught only in instants; (5) these variations are not dominated by the weather, they may be bright or dull under the most favorable circumstances, and dull or bright under the most unfavorable.

Our final list contains over a hundred and fifty positions; some appear so few times that independently they could not be claimed as bright lines. Although probably correct to within two in the fourth figure, yet they are useless for purposes of identification. The number of observations, however, places a means of discriminating at our disposal. If those lines, which are capable of being referred to a single substance, varied together, we may fairly consider that they belong to the same substance.

In this way we have identified *hydrogen*, presenting in addition to the four ordinary excitation lines to which we are accustomed, a large number, perhaps ninety, due to its low excitation spectra.

Oxygen presents eleven lines of its high excitation spectrum, and in addition the *glow of the negative pole* represented by sixteen lines.

Nitrogen presents probably eighteen lines of its high excitation spectrum, and in addition the *glow of the negative pole* represented by five lines.

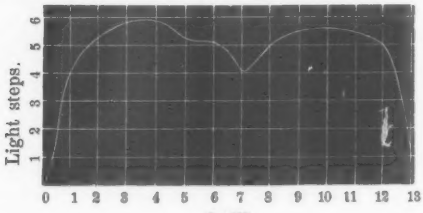
Carbon presents five lines, generally occurring together.

Compounds of carbon and hydrogen present seven lines, generally occurring together. Oxygen and carbon in combination present eight lines generally occurring together. Nitrogen and carbon in combination are probably represented by the most intense line of the cyanogen spectrum, but from the scantiness of the data we are unable to speak with certainty.

Magnesium is represented by five lines generally occurring together, and yet the traces of magnesium burning in hydrogen are very faint.

The whole of this evidence, the low temperature of the hydrogen spectrum, the apparent ease with which the hydrocarbon* compound forms, the fact that during its formation there is an increase in the star's variable light without accompanying evidence of combustion and the spectra of the negative glow, presents us with the fact of an electric discharge in which hydrogen plays the part of the positive pole, and oxygen and nitrogen the parts of the negative pole. From evidence presented by the bright line† stars, noting that, roughly speaking, the high erexcitation hydrogen belongs to the brighter, the lower to the fainter stars, we are inclined to think this charge the residual of that produced by chemical action, perhaps simply dissociation taking place in the interior. We will not stop here to recall to the student of terrestrial and cosmical physics the evidence presented by comets, by the magnetic needle, by certain bands of the solar spectrum, by sun spots, by the zodiacal light perhaps, and many similar phenomena, not only of an electric charge upon the sun, but also of a cold atmosphere between it and our earth.

We have studied these spectra with regard to their appearance in time, and find evidence of a force especially evident in the nitrogen negative glow, in the magnesium and in the hydro-



Light curve of β Lyræ. Observation by Sawyer.

gen, whose laws our short series does not permit us to determine, but which is probably the cause effecting the disappearance of the hydrogen lines in 1874,‡ and their reappearance in 1883, and is perhaps similar to that causing the sun spots.

We have also studied the spectra with regard to the variation of the star's light, a single period of which derived from observations by Sawyer is represented in the adjoining cut. And we find in the spectra of hydrogen, oxygen and their carbon compounds a simultaneous variation. To any one acquainted with Berthelot's§ work, upon the action of mixtures of these gases under an electric spark, this will appear quite natural. The rise in the curve from primary minimum to primary maximum corresponds to a period of increasing oxygen,

* Ann. Chim. et Phys., III, lxvii, 67, 1863. † The Astron. Jour., No. 4, vol. vii.
‡ Astronomische Nachrichten, No. 2581. § Comptes Rendus, t. lxviii, 1869.

of increasing hydro-carbon, and of an almost entire absence of carbonic acid. The downward slope to secondary minimum corresponds to a period abundant in carbonic acid, almost wanting in oxygen with variable evidences of hydro-carbon. The remaining portion of the curve corresponds to a period in which the evidences of hydro-carbon, oxygen, and carbonic acid are irregularly variable; as would be the case if the light waxed and waned by a series of undulations similar to those which Chandler* tells us are actually observed. The final slope corresponds to a period of decreasing carbonic acid, increasing hydro-carbon, increasing oxygen, preparing as it were for a conflagration at primary minimum, and such apparently takes place. It is of interest to remark that hydro-carbon probably formed a part of the spectra of both Nova Cygni and the star near χ Orionis, but was only traceable near the star's maximum.

Recalling Lockyer's result in the study of the solar atmosphere, agreeing as it does with certain observations which we have quoted above, we may picture to ourselves the condition of the stellar atmosphere, and the action therein somewhat as follows: An outer layer of hydrogen positively electrified, an inner layer of oxygen negatively electrified, and between them a layer of carbon mingling on its edge with hydrogen. The electric spark passing through the mixture forms the hydro-carbon compound, whose molecular weight carries it into the oxygen region where combustion ensues with the formation of carbonic acid and aqueous vapor, both of which descending under the influence of their molecular weight are again dissociated by internal heat, and return to their original positions. Under the insight which this result gives we have found the spectrum of the nebulæ† referable to low excitation hydrogen, the spectra of the bright line stars referable to high excitations oxygen and hydrogen of higher or lower excitation according as the central star is of a high or low magnitude, and as far as the accuracy of the observations permits, τ Coronæ, Nova Andromedæ, Nova Cygni and the star near χ Orionis itself a variable, likewise referable to the same spectra similarly conditioned. There is also reason for thinking that a similar atmosphere in similar physical conditions, lies between us and the sun, and it seems as if we might consider that from the faintest nebula to the most highly finished star we have but progressive stages of the phenomenon here presented. To observe, to differentiate, to classify, to interpret, presents a vast field of deep interest and high promise. This line of investigation, however, will appreciate both new work in the laboratory and new methods with the telescope. To prepare these is now our charge; later we hope, under some clearer sky, to reënter the field.

* Chandler. Astronomical Journal, vol. vii, No. 1. † Ibid., vol. vii, No. 6.

ART. XV.—*Phenacite from Colorado;* by SAMUEL L. PENFIELD. *With notes on the locality of Topaz Butte;* by WALTER B. SMITH.

THE occurrence of phenacite in the United States was first mentioned by Messrs. Cross and Hillebrand,* who published a short description and figure of a crystal occurring with microcline (amazon stone) from the Pike's Peak region, El Paso Co., Colorado; later these same authors† gave a more detailed description of more complicated crystals from Florissant, in El Paso Co. At about the same time Mr. W. E. Hidden‡ mentioned the occurrence of phenacite from Florissant; a second note by him, recently§ published, contains some crystallographic notes and two figures by Prof. Des Cloizeaux, of Paris. Some additional facts regarding the crystallization of this remarkable mineral with some new figures may not be without interest to those who are especially interested in American minerals. In addition to the crystals from the above mentioned locality, I have also, through the kindness of Mr. Whitman Cross, been provided with crystals from an entirely different locality, and with different associations and crystalline habits, which are especially worthy of description.

The lenticular crystals which have already been described are from Topaz Butte, near Florissant, and about sixteen miles from Pike's Peak. In studying them, the first point noticed is their great similarity in habit to those described and figured by N. v. Kokscharow,‖ from the Ilmengebirge, Urals, where they occur with the same associations on amazon stone. All of the forms mentioned by Kokscharow occur on the crystals from Topaz Butte, and besides them I have found no others. His figures also represent very closely the habit of the crystals. The specimens which I have examined include those in the collection of Prof. Geo. J. Brush, the Yale College cabinet, and two loose crystals from the collection of Mr. C. S. Bement, of Philadelphia. The forms which have been identified are as follows: they are of especial interest because belonging to the rhombohedral-tetartohedral division of the hexagonal system.¶

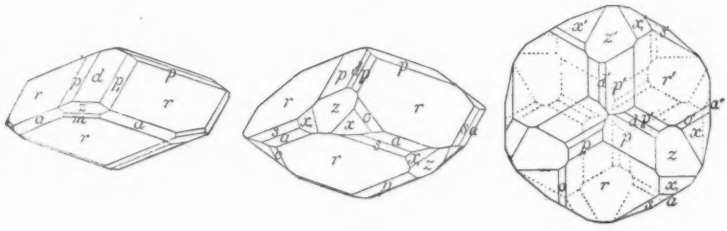
Rhombohedrons 1st order.	Rhomb. 2d order.	Rhomb. 3d order.	Prisms.
r, $10\bar{1}1$, $+1$	p, $11\bar{2}3$, $r\frac{2}{3}$-2,	x, $\bar{1}3\bar{2}2$, $-r\frac{3}{2}$-$\frac{3}{2}$	a, $11\bar{2}0$, i-2
z, $01\bar{1}1$, -1	p_1, $2\bar{1}\bar{1}3$, $l\frac{2}{3}$-2,	x_1, $12\bar{3}2$, $-l\frac{3}{2}$-$\frac{3}{2}$	m, $10\bar{1}0$, I
d, $01\bar{1}2$, $-\frac{1}{2}$	o, $4\bar{2}\bar{2}3$, $l\frac{1}{3}$-2,	s, $21\bar{3}1$, $+r$ 3-$\frac{3}{2}$	
μ, $02\bar{2}1$, -2			

* This Journal, III, xxiv, 282. † Bulletin No. 20 of U. S. Geological Survey.
‡ This Journal, III, xxix, 249. § This Journal, III, xxxii, 210.
‖ Materialien zur Mineralogie Russlands, ii, 322.
¶ As these forms are tetartrohedral, ± should be understood before each of the Dana symbols.

In addition to the above, Des Cloizeaux identified a third prism k, $41\bar{5}0$, i-$\frac{5}{4}$, and a new plane which he lettered z, $13\bar{4}4$, $-l$ 1-$\frac{4}{3}$ which were not identified on the crystals which I have examined. In lettering the forms I have followed Koksharow, with only a few deviations, r, z, μ and m above equal R, r, m and g respectively of other authors.

All of the crystals which I have seen occurring on the feldspar are lenticular in shape, resulting from the slight development of prismatic and predominance of rhombohedral forms. Fig. 1 represents the form of crystals which occur with topaz on a brownish, lamellar albite. This specimen is in Prof. Brush's collection, labeled only Pike's Peak: the crystals are a trifle simpler than those occurring on the amazon stone from Florissant, and it may be that they are from some other special locality in the Pike's Peak region. Here the rhombohedron r predominates, d is large, and the two forms p and p_1 are, as is usually the case, about equally developed; the other forms z, a and m are at times wanting, and scarcely ever more developed than shown in the figure. The crystals occurring on the amazon stone are usually more highly modified. Fig. 2 represents the forms which were observed on a crystal from Mr. C. S. Bement's collection, while fig. 3 is a basal projection of the same with the position of the lower faces dotted in, which is well suited to show the tetartohedral character of the crystal.

1. 2. 3.



All of the forms mentioned in the above list are shown in these figures except μ and m; μ was not observed on this crystal, and m only as a very narrow face. While the usual custom has been followed of drawing these crystals so that an edge of the positive rhombohedron above runs toward the observer, the basal projection has been so turned that the positive rhombohedron above is in front, so that the indices in the above list of forms can be better understood. The relative size and position of the rhombohedrons of the first order can readily be understood from the figures. Of rhombohedrons of the second order there is a decided predominance in size of p to the right

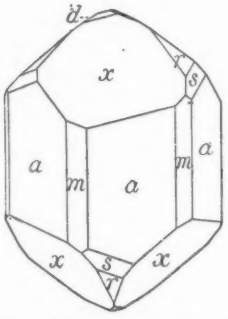
of r, over p, to the left; unfortunately the crystal had been so attached that the relative size and position of these faces on the lower side could not be observed; on the top of the crystal, however, the three alternating faces were large, the other three small, as shown in the figure: o occurs only to the left of r, being present three times above and three below. Of rhombohedrons of the third order, x and $x_,$ occur under the negative rhombohedron, z, both to the right and left, and are about equally developed, while s occurs under the positive rhombohedron r to the right only. These forms have not only the same symbols, but also the same position with reference to the positive rhombohedron on the Colorado as on the Russian phenacites, as shown by a comparison with the figure of Kokscharow.

The remaining crystals, which are to be described, are from an entirely new locality, Mt. Antero, in Chaffee Co., about one hundred miles southwest of Denver, fifty-five miles from Topaz Butte, and sixty-five miles a little to the south of west from Pike's Peak. Mt. Antero is over 14,000 ft. high, and the phenacites were found by a prospector (whose name I do not know) at one spot on the surface, in a streak up and down the steep slope of the mountain and above the timber line, probably at an altitude of 12,000 feet. The crystals were given by the discoverer to the Rev. R. T. Cross,* of Denver. So far as known the country rock is granite, and the associations are beryl, quartz and feldspar. The suite of specimens in the author's possession consists of eight specimens of pale, bluish green aquamarine, upon three of which the crystals of phenacite are implanted. The crystals are prismatic, and the largest, about 7^{mm} in length, is implanted in an inclined position upon the basal plane of the beryl, while others are scattered irregularly over the prismatic face. The specimens were probably not found in place, as the edges of the crystals are more or less rounded and nicked, as if they had rolled around in contact with other hard minerals. The beryl crystals are deeply striated parallel to the vertical axis and eaten out, having perhaps furnished the material for the formation of the phenacite. The habit of the phenacite crystals is remarkable, and is shown in fig. 4 in ordinary projection, and in fig. 5 in basal projection, the figures being placed in the same relative position as those above. In the prismatic zone the prism of the second order a prevails, while m is always small, in some cases wholly wanting. The crystals are terminated mainly by the rhombohedron of the third order x, $\bar{1}3\bar{2}2$, $-r\frac{3}{2}$: The unit rhombohedron r is small and in a zone between it and the prism a is the rhombo-

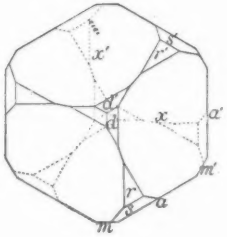
* Some notes upon this locality by the Rev. R. T. Cross will be found on a later page of this Journal.

hedron of the third order *s*. At the top of the crystal are the three small faces of the minus rhombohedron *d*. The prismatic faces are striated not only vertically, especially that part of the prism farthest away from the *s* face, but also near each *s* face parallel to the intersection between *s* and *a*. These two sets of striations do not cross but meet along a line run-

4.



5.



ning in an inclined direction across the *a* face; the *s* and *r* faces, especially the former, are also striated parallel to the intersection between *s* and *a*. These striations point to vicinal faces, prisms and rhombohedrons of the third order, but no definite indices could be assigned to them. The *x* faces are not smooth and polished, but covered with little prominences with curved unsymmetrical contours. Crystals with exactly this habit have previously been described by Prof. M. Websky,* of Berlin, from an unknown locality in Switzerland, and they are the only crystals, so far described, which are terminated mainly by rhombohedrons of the third order. It is interesting also to note that, while in the Russian localities the crystals of phenacite occurring on amazon stone are lenticular, as is the case also in Colorado, the crystals from the emerald mines of Katharinenburg are prismatic, terminated however not by rhombohedrons of the third, but by those of the first and second order.

In the following table the angles are given which were measured for the identification of the above mentioned forms and also the corresponding angles calculated from the fundamental angle of Kokscharow, $r \wedge r'$, $10\bar{1}1 \wedge \bar{1}101 = 63° 24'$, $c = 0{\cdot}66106$. In measuring those faces which are deeply striated, and where there were a number of reflections of the signal the most prominent reflection was chosen.

* Jahrb. f. Min., 1882, i, 207.

	Lenticular crystal from Topaz Butte.	Prismatic crystal. Mt. Antero.	Calculated, Kokscharow.
$r \wedge r$ $10\bar{1}1 \wedge \bar{1}011$	63° 14′	63° 24′	63° 24′
$r \wedge d$ $10\bar{1}1 \wedge 01\bar{1}2$	31° 40′	31° 30′	31° 42′
$r \wedge p$ $10\bar{1}1 \wedge 11\bar{2}3$	20° 4′		20° 4′
$r \wedge o$ $10\bar{1}1 \wedge 42\bar{2}3$	19° 19′		19° 18′
$r \wedge x$, $10\bar{1}1 \wedge 12\bar{3}2$	27° 42′		27° 43′
$r \wedge s$ $10\bar{1}1 \wedge 21\bar{3}1$	29° 59′		29° 57′
$r \wedge a$ $10\bar{1}1 \wedge 11\bar{2}0$	58° 17′	58° 13′	58° 18′
$d \wedge z$ $01\bar{1}2 \wedge 01\bar{1}1$	16° 26′		16° 28′
$z \wedge \mu$ $01\bar{1}1 \wedge 02\bar{2}1$	19° 25′		19° 28′
$s \wedge a$ $21\bar{3}1 \wedge 11\bar{2}0$		28° 52′	28° 21′
$x \wedge x'$ $\bar{1}3\bar{2}2 \wedge \bar{2}\bar{1}32$		75° 48′	75° 57′

In closing, I wish to express my obligations especially to Mr. Whitman Cross, of the U. S. Geological Survey, for the information concerning the localities and associations of the Colorado phenacites, and to Rev. R. T. Cross, Prof. Geo. J. Brush and Mr. C. S. Bement for the material which they have placed at my disposal.

Mineralogical Laboratory, Sheffield Scientific School, Nov. 19th, 1886.

Notes on the Crystal Beds of Topaz Butte;* by WALTER B. SMITH.

The "crystal beds," from which by far the greater number of the specimens labeled *Pike's Peak* have actually come, are situated about 20 miles northwest of that point. This locality has been known and worked for about 20 years. Topaz Butte, a sharp point five miles due north from Florissant, marks the southern limit of the "crystal beds." It is the highest of a chain of similar, bare granitic points extending several miles to the north and known as the Crystal Peaks. A rectangle, beginning at Topaz Butte and running six miles north along the above ridge, and extending three miles eastward, will include most of the pockets from which the beautiful amazon stone and smoky quartz crystals have been taken.

On the west side of the Crystal Peaks, pockets have been found scattered over an area equal perhaps to that on the eastern slope, but they are fewer by far in number. Phenacite and topaz have been found in three of these pockets, while neither mineral has been observed on the eastern side, though the formation, conditions and associations are apparently similar.

A pocket found in 1884, on a debris-covered slope about one and a half miles northwest of Topaz Butte, yielded the first phenacites and topazes that were found in this region, which have been described by Cross and by W. E. Hidden. The

* Extract from a paper read Oct. 3, before Colorado Scientific Society, to be published in vol. ii, part 2.

minerals associated with phenacite in this pocket are topaz, microcline, quartz (smoky and white), albite, fluorite, limonite (pseudomorph after siderite), columbite (very rare), and biotite. At this pocket the writer found fragments of topaz, albite, quartz, and microcline with phenacite attached. On one piece of albite were fourteen distinct crystals of phenacite on a surface about three-quarters of an inch square.

The largest phenacite ever found in this locality is a rough lenticular crystal about 15^{mm} in diameter. Most crystals are colorless, but those that have been entirely imbedded in gangue are generally of a faint wine color; one was observed having a smoky bluish tinge. All phenacites attached to microcline, here, as well as at the Specimen Rock locality, have been on the green or amazon stone variety. A few phenacite crystals have been observed in the interior of smoky quartz and of amazon stone crystals, these minerals showing no evidence of a secondary growth. Phenacites have also been found half in quartz and half in microcline when the two minerals are in contact. Other crystals seem to be of a later generation than the original minerals of the cavity, as they occur slightly attached to amazon stone, to albite coating microcline, and entirely imbedded in the limonite crust on some feldspars.

ART. XVI.—*The Norites of the "Cortlandt Series" on the Hudson River near Peekskill, N. Y.;* by GEO. H. WILLIAMS.

IN a former paper on the "Peridotites of the Cortlandt Series,"* the writer has described the most basic members of that extremely varied and interesting group of massive rocks which occupy the northwestern corner of Westchester County, N. Y. These peridotites are characterized by the presence of the mineral olivine and the almost complete absence of feldspar. They are most abundantly developed on the western edge of the area occupied by the Cortlandt rocks (Stony Point, on the west bank of the Hudson River, and in the southern part of Montrose Point) but are also met with at several localities in its southeastern portion. Quantitatively they make up but a small proportion of the whole series.

By far the larger majority of the Cortlandt rocks contain, as their most important constituent, a triclinic feldspar. Quartz and orthoclase also occur in some of them, although these minerals are comparatively rare. Other characteristic components are hypersthene, augite, hornblende and mica. Magnetite

* This Journal, Jan., 1886, p. 26.

and apatite are always present, though in varying quantities, and garnet is not uncommon, especially around the edge of the area.

The predominating rock-type within the Cortlandt area is particularly characterized by the presence of hypersthene. Throughout nearly the entire township east of the New York Central and Hudson River Railroad and also, to a considerable extent west of this, rocks of this class prevail; and still examples of the pure norite type, composed wholly of plagioclase and hypersthene, appear to be exceptional. In nearly all specimens biotite, hornblende and augite, either singly or together, accompany the hypersthene in every conceivable proportion and thus form gradual transitions into mica-diorite, hornblende-diorite and gabbro. These rocks are developed in considerable purity in the western portion of the township; and yet, throughout the entire Cortlandt region, intermediate and transitional forms are everywhere more abundant than well defined extremes. The naming and classification of particular specimens becomes a matter of great difficulty; and when it is remembered that to the mineralogical variety a great structural diversity is added, some idea may be formed of the number of different types which may be collected within this very limited district.

The constant occurrence of such transitional forms and the want of any regularity in the distribution of the pure types, makes it impossible to regard these rocks as anything but local modifications or special facies of one and the same mass. However great their mineralogical variety may be, they together form but a single geological unit.

As already stated there seems to be a peripheral distribution of those rock-types which, like diorite and gabbro, differ most widely from the prevailing norite. A possible connection between this fact and the proximity to these rocks of the mica-schists and limestones which surround or are enclosed in the massive area, the writer hopes to discuss, in connection with some chemical analyses, in a later paper.

At present only a petrographical description of the massive rocks themselves will be attempted. For this purpose the pure types will be treated in succession and about each will be grouped such varietal or transitional forms as are produced by the various admixtures of accessory constituents. Each class will be designated according to its prevailing non-feldspathic mineral as follows:

Class II,	hypersthene,	NORITE.
" III,	augite,	GABBRO.
" IV,	hornblende,	DIORITE.
" V,	biotite,	MICA-DIORITE.

Non-Chrysolitic Rocks.

Class II. *Norite.* (Esmark).

The application of the microscope and accurate optical methods have been instrumental in showing that many rocks formerly supposed to contain orthorhombic pyroxene are in reality devoid of this mineral. Many of the so-called "hypersthenites" of the older petrographers contain only a glistening, bronzy diallage (the "*diallage metalloide*" of Hauy). This peculiar luster is found to be in no way connected with an orthorhombic crystallization, and yet the microscopic studies of rocks have by no means tended to show that hypersthene is a less widely distributed mineral than was formerly supposed. On the contrary, orthorhombic pyroxene is constantly being found to be a more and more important rock constituent. Not only is it discovered to have an unsuspectedly wide spread occurrence in the younger volcanic lavas, but in the more basic of the older granular rocks true hypersthene is by no means a rare constituent. The localities for hypersthene-gabbro or hyperite are constantly increasing, wherever the older rocks are being studied.

Hypersthene rocks have long been known to be developed on an enormous scale in the Laurentian formation of Canada and northern New York, where they are called anorthosite or norite. True hypersthene is also known to have a wide distribution in the dark, fine grained gabbros of Maryland,* Delaware† and Pennsylvania. These rocks are members of the Archæan formation and resemble traps, although they are wholly different from the mesozoic diabase of the Atlantic border.

The occurrence of a considerable area of massive rocks in which hypersthene is the prevailing bisilicate, on the southern flank of the Archæan Highlands of New York, is very interesting in connection with the distribution of this mineral in the rocks of the Appalachian belt to the north and south of it.

The earliest identification of hypersthene in the Cortlandt rocks is, as far as I have been able to ascertain, that of Hermann Credner in 1865.‡ These rocks are described by Mather, in

*See Bull. U. S. Geol. Survey, No. 28, p. 18.

†F. D. Chester: Proc. Acad. Nat. Sci. Philadelphia, Oct. 14, 1884. Dr. Geo. W. Hawes also found hypersthene-gabbros abundant in the White Mts., N. H.

‡ It may be of interest to quote here a few sentences from Credner's description of these rocks, given in an article entitled "Geognostische Skizze der Umgegend von New York." He says: "Noch einige Meilen (von New York) nördlich wird der Gneiss sehr reich an Hornblende, bis diese den Glimmer noch und noch verdrängt, wodurch ein ausgezeichneter Hornblendeschiefer entsteht, welcher allmählig sein schiefriges Gefüge verliert und zu einem porphyrartigen Syenit wird, in dessen weisser Grundmasse grosse blättrige Hornblendeindividuen ausgeschieden liegen. Von diesem Gestein sollen wiederum Uebergangsstufen nach dem Hypersthenfels

his report on the geology of the first district of New York, as "syenite" and "hornblende rock."* The next notice of the occurrence of hypersthene in the rocks near Peekskill was given by Prof. Jas. D. Dana, who identified and described it in connection with his studies of the rocks of Westchester County.†

The comparative rarity of pure rock types in the Cortlandt Series above alluded to render various subdivisions under the hypersthene rocks necessary. I shall consider in succession:

1. Norite proper.
2. Hornblende Norite.
3. Mica Norite.
4. Hyperite or Augite Norite.
5. Pyroxenite.

1. *Norite proper.*

As already stated, hypersthene rocks which are entirely devoid of mica, hornblende and augite are extremely rare within the Cortlandt region. Indeed it may be doubted if any specimen of the absolutely pure norite type could be found; and yet such are occasionally met with as contain these minerals in very small quantities. These specimens are regarded as representing the norite proper.

Two thin-sections in Professor Dana's collection, prepared from specimens collected at the iron mine three-fourths mile N. 15° W. of Cruger's station, show the norite type in greater purity than any others which have come under the writer's notice. They are almost wholly free from the non-essential minerals, only occasional plates of a very dark biotite being observable. The ground-mass is here a rather coarse-grained mosaic of plagioclase. The hypersthene is present in well-defined individuals with a more or less rounded outline. This mineral is freer from inclusions and has a much lighter color than is usual in the Cortlandt norites.

nachzuweisen sein, welcher das hügelige aus steilen Bergkuppen bestehende Plateau bildet, das sich am linken Ufer des Hudson in östlicher Richtung von Peekskill, einer etwa 40 Miles von New York gelegenen Stadt, ausdehnt. Ich war verhindert diese Uebergänge genau zu verfolgen, habe aber ein feinkörnig-syenitisches Gestein beobachtet, welches grosse Partieen von grüner Hornblende umfasste, in welcher kupfer-glänzende, scharf-begrenzte Hypersthen-Individuen lagen. Diese Gesteinsart scheint die Mitte der Uebergangstufen zwischen Hypersthenit und Syenit einzunehmen. . . . . Nördlich von Peekskill geht der Hypersthenfels wieder in Syenit über. Das zwischen beiden liegende Gestein, welches Hornblende und Hypersthen zugleich enthält, habe ich auch hier beobachtet." —Zeitschrift der deutschen geologischen Gesellschaft.—Bd. xvii, 1865, p. 390. The gradual transition of the hypersthene rock into syenite and hornblende-schist does not in reality appear to exist.

* Geology of New York—Part I, Geology of the First District by Wm. W. Mather, 1843, p. 528.

† On the geological relations of the limestone belts of Westchester County, New York. This Journal, III, xx, p. 197, Sept. 1880.

Slide No. 118 of the Johns Hopkins University collection, is of a rock from the same locality as the two just mentioned. It is essentially the same as the preceding but contains as additional constituents pleonaste and garnet. The relation of the first of these minerals to the norite is very interesting and will be more fully described beyond. The garnet here forms narrow borders around the iron minerals. Here again the hypersthene and feldspar are unusually light colored and free from inclusions, a fact which may indicate that nearly all the iron present in the magma crystallized in the ores.

No. 43, from Shaw's blacksmith shop near the railroad crossing at Centerville on the road to Peekskill, exhibits a very interesting variety of the typical norite containing large porphyritic crystals of *orthoclase*. At first glance this rock in the hand-specimen appears like a medium grained aggregate of reddish brown feldspar and glistening bronzy hypersthene, but a closer examination reveals the presence of long, narrow cleavage surfaces of feldspar. Some of these measure as much as 10×60^{mm}! The crystals are elongated in the direction of the clinodiagonal axis, as may be seen from the direction of the cleavages. The highly reflecting surfaces are everywhere sprinkled with dull spots which the microscope shows to be inclusions of the other constituents in grains of the usual size. Here, therefore, we have another example of the structure which the writer has distinguished as *pœcilitic** in describing the hornblende of the Cortlandt peridotites.

* A careful examination of this feldspar leaves little doubt as to its being a true orthoclase. Its specific gravity, determined by the Thoulet solution and a Mohr's balance, is 2·615. The powder, which was completely isolated from the other constituents, gave a strong potassium reaction. A series of measurements on the reflecting goniometer gave, for the angle between the two cleavage planes, values varying from 89° 35′ to 90° 44′, a slight uncertainty being occasioned by the somewhat undulatory character of the cleavage surfaces. Stauroscopic determinations of the extinction angles, made on carefully detached cleavage pieces, yielded values averaging $5\frac{1}{2}°$ for $\infty P \infty$ (010) and 0° for 0P (001).

This feldspar also differs in several other particulars from the small reddish brown plagioclase crystals which, as usual, make up the greater part of the Cortlandt norite. Twinning lamellæ are altogether wanting in it, and its color is white, owing to the absence of the reddish dust which is always present in the plagioclase. Its appearance in the hand-specimen is fresh and glassy, while under the microscope it possesses to a high

* This Journal, Jan. 1886, p. 30. The word is here changed to the accepted form.

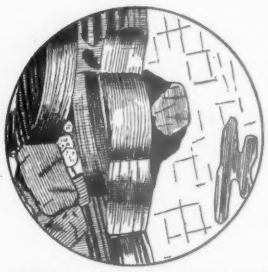
degree the peculiar "shagreen" surface, so characteristic of certain minerals such as olivine (fig. 1). This appears to be due to a vast number of very minute oval indentations which completely cover the surface wherever it is exposed.

1.

This occurrence of orthoclase in norite is very interesting and is quite in accord with determinations formerly made of the feldspars in these rocks by Prof. Dana and the late Dr. G. W. Hawes.*

The plagioclase, which composes most of the groundmass of this rock and also occurs occasionally as inclusions in the orthoclase, is shown by its specific gravity and extinction angles to be *Andesine*. The former, as determined by the Thoulet solution, is 2·674. The extinction angles are 4°–5° on 0P (001) and 10°–12° on $\infty P\breve{\infty}$ (010). In the groundmass of the rock these plagioclase individuals are crowded thickly together and are often bent or broken. In such cases they show most beautifully the increase in the number of twinning lamellæ where the strain has been greatest (fig. 2.)

2



Section No. 43. Bent and broken plagioclase crystals showing secondary twinning lamellæ. On the left and near the center hypersthene. On the right orthoclase enclosing an irregular plagioclase crystal. Plagioclase is represented between crossed Nicols in order to bring out its twinning structure.

Such a mechanical origin of twinning lamellæ in feldspar has been figured and described by van Werveke† and Judd,‡ but it would be difficult to conceive of finer examples of it than are to be found in this rock. In the groundmass these plagioclase crystals are well developed and have their characteristic lath-shaped form, but where they are imbedded in the orthoclase they show exceedingly irregular shapes as though they had been partially dissolved (fig. 1).

The hypersthene is generally arranged in groups of three or more crystals. These are intensely colored owing to the large amount of iron which they contain and show their characteristic trichroism ($\breve{a}$ = r = red; $\bar{b}$ = b = yellow; $\dot{c}$ = c = green) very vividly. In spite of their deep color, these hypersthene crystals are unusually full of the

* This Journal, Sept. 1880, p. 197.

† Neues Jahrbuch für Mineralogie, etc., 1883, ii, p. 97.

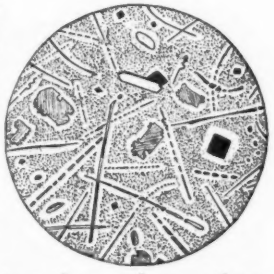
‡ Quarterly Journal of the Geological Society, Aug. 1885, p. 365.

red inclusions so characteristic of this species, a fact which would speak against their having been secondarily formed by "*schillerization*," which Professor Judd states is attended by a bleaching of the original mineral substance. The extinction of the mineral is in all sections parallel to the crystallographic axes. In sections parallel to the basal- or macropinacoids, the bisectrix may be seen to stand perpendicular to the face and the optical angle to be smaller in the latter case than in the former. This fact, taken in connection with the deep colors exhibited by the mineral, is sufficient to place its nature as true hypersthene beyond a doubt.

The only other constituents observed in this rock are biotite, irregularly dispersed in small quantities, and a considerable amount of apatite and magnetite or ilmenite.

All the feldspar of this norite, both orthoclase and andesine, is filled with inclusions of such great beauty and delicacy that they seem to merit a description, especially on account of their bearing upon the former remarks of the writer regarding Professor Judd's theory of Schillerization.* These inclusions, which are represented in fig. 3 as magnified about 350 diameters, consists of plates, rods and minute dots.

3.



1. *The plates.*—The color of these is either red, grading as they become thinner into shades of orange and yellow; or greenish-gray. They are sometimes hexagonal, sometimes rectangular and sometimes irregular in shape. Almost always they are finely serrated for a portion of their edge. The largest measure about 0·04 × 0·01 mm. From this size they grade down to the minutest dots, always, however, transparent, homogeneous and very sharply outlined. These plates do not exercise any influence upon polarized light. This is, however, on account of their extreme thinness as compared with the mineral in which they are imbedded. These plates very strongly resemble extremely thin crystals of hematite (micaceous iron, eisenglimmer) and the writer is inclined to regard them as composed of this substance.

2. *Rods.*—When very minute, the above described plates are frequently arranged in parallel rows, which grade insensibly, into long, hair-like rods. These are sometimes discontinuous, a mere series of dots, through a part or the whole of their length; sometimes they are thickened in certain places. Often these rods may be seen to be continuous with the plates, and, like them, they are always transparent with a brown color except

* This Journal, January, 1886, p. 33.

when of the extremest thinness. These rods are often curved and closely resemble the trichites seen in certain volcanic glasses. *There is no parallelism whatever in the arrangement of these bodies*, a fact which has an important bearing on their mode of origin.

3. *The dots.*—These are extremely minute, opaque, globulitic bodies, which may be regarded either as very small plates or as the elements of which the rods are composed. They vary somewhat in size, the smallest forming the fine reddish-brown dust, which imparts the characteristic color to the andesine and which no power of the microscope can resolve. These dots resemble the globulites in certain obsidians in the same way in which the rods resemble trichites.

The mutual arrangement of these three classes of inclusions throws considerable light on their nature and origin. As above remarked, there seems to be no regularity in their direction, as would be required by the "solution planes" of Judd; and yet there is a very decided regularity in their arrangement in zones in the enclosing crystal. As a rule, the center of the plagioclase individuals is occupied by an indiscriminate mass of rods and plates, which is surrounded by a zone filled only with reddish dust. Outside of this there is almost always an exterior zone quite free from inclusions of any kind. This arrangement is essentially the same as that recently described by the writer in the bytownite of the Baltimore gabbros.*

The dust-like globulites are also present in the space between the rods and plates near the center of the crystal. Then, however, there is always a perfectly clear space around each larger inclusion and *the width of this clear zone depends upon the size of the inclusion which it surrounds.* It is widest about certain occasional octahedral crystals of magnetite (see fig. 3). The bearing of this phenomenon upon the mode of origin of the inclusions is too apparent to need further elucidation.

The fact that the arrangement of these inclusions is altogether independent of the numerous bendings and cracks, mentioned above as so common in this feldspar, also speaks strongly against their secondary origin.

A careful and prolonged study of the form, size and arrangement of these inclusions has convinced the writer that they are original and represent the form in which the iron first separated from the magma. This was probably simultaneous with the crystallization of the feldspar, as is indicated by the uniformity of their zonal arrangement.

Such red globulitic dust is well known to be the coloring matter of the feldspar in many of the quartz porphyries. The sunstone of Tvedestrand owes its peculiar luster to plates of

* Bulletin of the U. S. Geological Survey, No. 28, p. 21, 1886.

hematite, similar to those found in the well known perthite, or even in some crystals of carnallite.

Although such inclusions are almost always present in the older rocks which have originated at great depths, they are by no means unknown in certain minerals of volcanic rocks which have cooled at the earth's surface. Those above described in the plagioclase of the Cortlandt norite are almost identical in both form and disposition with the ones which Prof. Hermann Vogelsang so admirably figured in 1874 from the nosean of Rieden.* Mierisch has also very recently described and figured similar bodies in the sodalite and apatite found in druses of the limestone blocks ejected from Monte Somma.† ‡

Although the norite is the prevailing type of massive rock throughout Cortlandt township, still the pure aggregate of plagioclase and hypersthene is comparatively rare. In almost every case either biotite or hornblende or monoclinic pyroxene is present, and often two or all three of these together in accessory quantities, forming transitions to the mica-diorite and gabbro which are common modifications of the same continuous mass, especially around its periphery. The writer has therefore designated all rocks in which one-half or more of the nonfeldspathic constituents was hypersthene as norite, and named varieties of this after the prevailing accesssory component.

* Ueber die natürlichen Ultramarinverbindungen. Bonn, Taf. I.

† Tschermak's Min. und Petrog. Mitth., viii, pp. 166 and 183.

‡ The writer does not wish to imply by the above observations any direct opposition to Professor Judd's theory of schillerization. Through the kindness and liberality of this gentleman he has been enabled to study a suite of sections of the Scottish rocks upon which this theory was based, and can express himself as convinced of the correctness of Prof. Judd's conclusions as far as these rocks are concerned. The idea of schillerization, which Prof. Judd has so admirably developed, is to be welcomed as a new and most valuable addition to what microscopical petrography has accomplished. It is doubtless capable of a wide application and will serve to clear away many difficulties. The writer desires only to call attention to the fact that it is unsafe to ascribe *all* the inclusions occurring in the old granular rocks to the effects of what Professor Judd calls schillerization, even when these apparently resemble such as have been undoubtedly produced in this way. How often is it observed that nature employs diverse means to accomplish approximately the same result! Two investigators, commencing with the study of effects which may with certainty be attributed to very different causes, often succeed in tracing these by insensible transitions to a common ground, where the phenomena observed may be ascribed with almost equal right to the one cause or the other. Here two opposing views may be defended with excellent reasons, which depend largely upon the direction from which the subject was approached. Both may be right and yet particular cases may arise where it is impossible to decide between them.

Thus it would appear that both original and secondary inclusions may occur in the constituents of the granular, deep-seated rocks and that the similarity between them may be so great as to occasion difficulty in referring certain cases to the one class or the other.

2. Hornblende Norite.

No. 117, from the same iron mine north of Cruger's Station as 118, is like this except that it contains an abundance of compact, dark green hornblende. This is present in good-sized individuals without crystal outline. The color is greenish-brown, with a trichroism: a=light yellow; b=dark greenish brown; c nearly like b. Absorption, a<b<c. Around frequent magnetite inclusions the color is generally bleached out to a clear, light green.

No. 119, from Montrose station, south of Peekskill, is quite like the foregoing except that its hornblende is in larger areas, often enclosing the other constituents. Its color is brown and in its inclusions, pleochroism and general character, it appears to be wholly identical with the hornblende described at length as occurring in the Cortlandt peridotites. (See this Journal, Jan., 1886, p 31.

No. 125 was collected on the road leading S.E. from Peekskill, directly east of Blue Mountain and just about in the middle of Cortlandt Township. In the hand specimen well formed, glistening black hornblende crystals are seen to be thickly scattered through a grayish groundmass of feldspar and hypersthene. These hornblende crystals vary in size, the largest being 12–15 mm. in length. Other representatives of the hornblende norites are specimens Nos. 50*a* and 50*b* from the "Butler Section," on the road from Montrose Station to Montrose Point, to be described beyond. The amount of hornblende is so great in these rocks that they might perhaps be better classed as diorites, and yet so much hypersthene is present that it was thought better to place them here. They are very fresh and coarse-grained aggregates. The hornblende is of the greenish kind described in section No. 117. The hypersthene is in much smaller individuals imbedded in the hornblende.

All of these rocks contain a greater or less quantity of biotite and so grade into the next variety.

(To be concluded.)

ART. XVII.—*A method for subjecting living Protoplasm to the action of different liquids;* by GEORGE L. GOODALE.

IN the studies of Loew and Pokorny, and of Pfeffer, on the action of very dilute solutions on living vegetable protoplasm, the objects under examination were generally exposed to large quantities of the solutions and thence transferred to the field of the microscope. It is indispensable in such investigations that the living object should be exposed to the action of a large quantity of the liquid.

To obviate the necessity of transferring the specimen from the litre-flask to the stage of the microscope, I have recently made use of an apparatus by which all handling of the specimen is avoided, and yet by which the object can be placed under the action of as large a quantity of liquid as may be desirable.

Reduced to its simplest terms, the apparatus consists of a small number of ordinary "chlorid of calcium jars" (i. e. tall slender jars provided with an opening near the base), which are connected by means of "three way" tubes, with a common tube of small size. The latter tube is inserted into the side of a microscopic-cell of simple construction. The best cells for the purpose are made of soft rubber, firmly cemented to the slide, and provided with an inflow and an outflow. The object to be examined is held without injurious pressure on the under side of the thin glass cover, either by delicate floats of glass, or better, by threads of glass fastened by wax. As soon as the object has been put in place, and the observer is convinced that it has suffered no injury by manipulation, the flow of liquid is allowed to begin by slightly opening one of the cocks or clamps connected with one of the three-way tubes. The object becomes at once bathed in the liquid, and may be subjected to its action either under a continuous slow or rapid flow, or to the action of another liquid which may be substituted by shutting off one and turning on another current. In my repetition of Pfeffer's interesting experiments, I was enabled in this manner to wash the object with pure water after every exposure, without removing it from the stage of the microscope.

It should be further said that the same apparatus also serves for the study of differential staining of tissues by various coloring matters.

By a slight modification, it may be applied also to the examination of the effect of different liquids with regard to their plasmolytic power (de Vries's experiments in Plasmolysis).

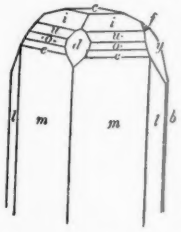
The application of this apparatus to the cultivation of organisms under different conditions of nutriment and the like, is obvious. Fresh solutions in any amount and number can be brought into contact with the submerged parts without even momentary exposure of the parts to the air.

And lastly, by a slight modification of the apparatus, it is possible to examine without disturbance of the growing plants the character of the acid given off by the extremities of roots during growth.

By due attention to temperature and to the height of the column of liquid in the jars, all the necessary physical conditions for studies of this character can be kept well under control.

Art. XVIII.—*On the Topaz from the Thomas Range, Utah;** by A. N. Alling.

The topaz crystals under examination were selected out of a considerable number in the cabinet of Professor Brush, from the locality in Utah in the Thomas Range, forty miles north of Sevier Lake, where they occur in rhyolite.† They vary from 3mm to 10mm in length, and are perfectly clear and colorless. The planes for the most part are very highly polished, though vicinal planes appear in a number of cases to disturb the accuracy of measurements. The habit to which most of the crystals conform is shown in the figure. The observed planes are:



Pinacoids $\breve{b}$ (010, $\bar{\imath}$-$\breve{\imath}$), c (001, O); prisms m (110, I), l (120, $\bar{\imath}$-$\breve{2}$); macrodome d (201, 2-$\bar{\imath}$); brachydomes f (021, 2-$\breve{\imath}$), y (041, 4-$\breve{\imath}$); pyramids i (223, $\frac{2}{3}$), u (111, 1), o (221, 2), e (441, 4).

The following angles, each representing the mean of a number of careful measurements with a Fuess compound goniometer, were taken as fundamental:

$$y \wedge y' \; 041 \wedge 0\bar{4}1 = 124° 41' 45''$$
$$u \wedge u' \; 111 \wedge \bar{1}11 = 91° 12' 0''.$$

From these angles the axial ratio was calculated, viz:

$$\breve{a} : \bar{b} : \dot{c} = 0{\cdot}5285 : 1 : 0{\cdot}47715.$$

It is interesting to note that these values approximate very closely to those obtained by von Kokscharow,‡ upon the Siberian crystals; he gives:

$$\breve{a} : \bar{b} : \dot{c} = 0{\cdot}52854 : 1 : 0{\cdot}47698.$$

On the other hand, the axial ratios for crystals from Ehrenfriedersdorf, Altenberg, Schneckenstein and Brazil, vary from both more or less widely (compare Grünhut, Zeitsch. Kryst., ix, 113). Some of the calculated and measured angles on the Utah crystals, in addition to those given above, are as follows:

		Calculated.	Measured.
$c \wedge f$	$001 \wedge 021$	$= 43° 39'$	$43° 39'$.
$c \wedge i$	$001 \wedge 223$	$= 34° 15'$	$34° 15'$.
$c \wedge o$	$001 \wedge 221$	$= 63° 58'$	$63° 57'$.
$c \wedge e$	$001 \wedge 441$	$= 76° 14\frac{1}{2}'$	$76° 12'$.
$u \wedge u'''$	$111 \wedge 1\bar{1}1$	$= 39° 0'$	$39° 1'$.
$o \wedge o'''$	$221 \wedge 2\bar{2}1$	$= 49° 39'$	$49° 39'$.
$y \wedge e$	$041 \wedge 441$	$= 59° 11'$	$59° 9'$.
$m \wedge m'''$	$110 \wedge 1\bar{1}0$	$= 55° 43'$	$55° 44'$.

* Abstract of a college thesis written June, 1886.

† Compare W. Cross, this Journal, xxxi, 437, June, 1886.

‡ With v. Kokscharow the vertical axis has double the length taken here.

Advantage was taken of a natural prism to measure the indices of refraction β and γ. Further, the optic axial angle was also obtained from a cleavage section. The values obtained are as follows:

$\beta = 1{\cdot}6104$ for yellow (sodium) $= 1{\cdot}6075$ for red (lithium).
$\gamma = 1{\cdot}6176$ " " $= 1{\cdot}6148$ " "
$2E = 126° 24'$ for yellow.
Also $2V = 67° 18'$ and $a = 1{\cdot}6072$ calculated.

ART. XIX.—*On a Simple and Convenient form of Water Battery;* by HENRY A. ROWLAND.

FOR some time I have had in use in my laboratory a most simple, convenient and cheap form of water battery whose design has been in one of my note-books for at least fifteen years. It has proved so useful that I give below a description for the use of other physicists.

Strips of zinc and copper, each two inches wide, are soldered together along their edges so as to make a combined strip of a little less than four inches wide, allowing for the overlapping. It is then cut by shears into pieces about one-fourth of an inch wide, each composed of half zinc and half copper.

A plate of glass, very thick and a foot or less square, is heated and coated with shellac about an eighth of an inch thick. The strips of copper and zinc are bent into the shape of the letter U, with the branches about one-fourth of an inch apart, and are heated and stuck to the shellac in rows, the soldered portion being fixed in the shellac, and the two branches standing up in the air, so that the zinc of one piece comes within one-sixteenth of an inch of the copper of the next one. A row of ten inches long will thus contain about thirty elements. The rows can be about one-eighth of an inch apart and therefore in a space ten inches square nearly 800 elements can be placed. The plate is then warmed carefully so as not to crack and a mixture of beeswax and resin, which melts more easily than shellac, is then poured on the plate to a depth of half an inch to hold the elements in place. A frame of wood is made around the back of the plate with a ring screwed to the center so that the whole can be hung up with the zinc and copper elements below.

When required for use, lower so as to dip the tips of the elements into a pan of water and hang up again. The space between the elements being $\frac{1}{16}$ inch, will hold a drop of water which will not evaporate for possibly an hour. Thus the battery is in operation in a minute and is perfectly insulated by the glass and cement.

This is the form I have used, but the strips might better be soldered face to face along one edge, cut up and then opened.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Isopycnic curves.*—Von Wroblewsky proposes to represent graphically the relations between the liquid and the gaseous states of matter by a system of equal density curves, which he calls isopycnic lines. Hitherto these relations have been graphically represented by curves of uniform temperature (isothermals) in which the pressure and the volume are the variables. In the new method the temperatures are laid down as abscissas and the pressures as ordinates. In the memoir the application of the method is shown for carbon dioxide, one of the substances for which the observed data are the most complete. An inspection of the curve shows distinctly that our knowledge of changes of state such as these is, especially in the vicinity of the liquefying point, very incomplete and in part incorrect. Moreover the author concludes that, even above the so-called critical temperature, there is a distinct difference between the liquid and the gaseous states, although this difference is very small.—*Wien. Monatsh. f. Chem.*, vii, 383; *Ber. Berl. Chem. Ges.* xix, 728, (*Ref.*) Nov. 1886. G. F. B.

2. *The Vapor-pressure of Hydrated Salts.*—Müller Erzbach has continued his researches upon the constitution of hydrated salts as determined from the pressure exerted by the vapor of the water they contain, measured at ordinary temperatures. This he experimentally determines from the loss of weight which two identical tubes, one of which contains the hydrated salt in question, the other water, simultaneously suffer, when placed in an atmosphere dried by means of sulphuric acid. The ratio of this loss of weight in the two cases the author regards as rigorously equal to the ratio of the elastic forces of the water vapor in the two tubes. Measured in this way, he finds that the evaporation from hydrated salts in completely dry air gives constant dissociation-pressures. The present paper gives the results obtained with nitrates and hydrates. Calcium nitrate for example, $CaN_2O_6.(H_2O)_4$ loses its water under a dissociation-pressure of 0·06 to 0·07. A white crystalline mass, left after evaporating an aqueous solution of the nitrate over sulphuric acid in rarefied air, contained only three molecules of water, of which one was given up at a pressure of 0·10 to 0·11, while the two others were evolved at the lower pressure of 0·04. Hence the author represents the constitution of this salt as $\frac{Ca\,N_2O_6+(H_2O)_2}{H_2O}$. If a fourth molecule of water be added, about one-half of this water is evolved under the pretty constant pressure of 0·27 to 0·36; the pressure then falls to 0·08 to 0·07, and before this water is entirely given up, the pressure reaches 0·04, as above. Strontium nitrate,

$SrN_2O_6.(H_2O)_4$ gives up all its water under the moderate pressure of 0·61 at 12·4°; and hence its water molecules cannot be separated in the formula. Zinc nitrate $ZnN_2O_6.(H_2O)_6$ showed for two of the water molecules a pressure of 0·18 at 16·1°, which fell rapidly during the evaporation of the third molecule to 0·025 and then became insensible. Hence its formula is $\frac{ZnN_2O_6.(H_2O)_2}{H_2O}+(H_2O)_2$. By heating this salt to 100°, Graham found that three molecules of water were driven off and the residue $ZnN_2O_6.(H_2O)_3$ left. Barium hydrate $BaH_2O_2.(H_2O)_8$ loses the eighth molecule of water under the relatively high pressure of 0·88 to 0·92, then five molecules at the pressure of 0·18 to 0·22, then two molecules at 0·10 to 0·12 and retains one molecule; so that the formula of composition of this hydrate is $\frac{BaH_2O_2.H_2O}{H_2O}+(H_2O)_5$. Strontium hydrate $SrH_2O_2.(H_2O)_8$ loses one water molecule at 0·73 at 17·6° and six molecules at the pressure 0·27 at 18·5°, while the last molecule remains with the hydrate. Hence this salt has the formula $\frac{SrH_2O_2.(H_2O)}{(H_2O)_6}+H_2O$.—*Ber. Berl. Chem. Ges.*, xix, 2874–2876, November, 1886. G. F. B.

3. *On the solidification of Hydrogen fluoride, phosphide and antimonide.*—Hydrogen fluoride, according to Olszewsky, prepared by heating dry hydro-potassium fluoride and condensing the product in a platinum receiver cooled by ice and salt, solidifies at −102·5° as a transparent crystalline mass fusing at −92·3°. In the absence of water the liquid does not attack glass. Hydrogen phosphide boils in the vicinity of −86° and solidifies as a crystalline semi-transparent mass at −133·5°, beginning to fuse again at −132·5°. Hydrogen antimonide, evolved by the action of dilute sulphuric acid upon an alloy of two parts antimony and three parts of zinc, crystallizes at −102·5° as a snow-white mass, fusing at −91·5° to a colorless liquid, which even at the low temperature of −56° to −66° partially decomposes with separation of antimony. It boils at −18°.—*Wien. Monatsb. f. Chem.*, vii, 371–374; *Ber. Berl. Chem. Ges.*, xix, 739 (*Ref.*), Nov., 1866. G. F. B.

4. *On the Fluorescence of certain Metallic Oxides, when exposed to an Electric discharge in a high vacuum.*—Lecoq de Boisbaudran has examined several of the metallic oxides by the method of Crookes, with a view to determine the character and intensity of their fluorescence under these conditions, either alone or mixed with other substances. Of these oxides that of manganese is remarkable for the variety of the colors it gives, and for the characteristic band in its fluorescent spectrum. Neither manganese sulphate nor manganese peroxide perceptibly fluoresces after calcination, when alone. But mixed with calcined calcium sul-

phate (which alone gives only a weak continuous spectrum) even in the proportion of only one per cent, the mixture fluoresces with a magnificent green color, reaching its maximum brilliancy when five per cent of the oxide is present. Calcium carbonate, which does not fluoresce when not previously heated, and which fluoresces violet-blue after calcination, gives, on adding a trace of manganese, a magnificent orange-yellow color. Magnesium sulphate alone, after heating to redness, fluoresces feebly greenish-white; but a trace of manganese causes it to fluoresce of a superb red color. Zinc sulphate, calcined, fluoresces feebly pale rose color; but with manganese, it gives a splendid orange-red color. Cadmium sulphate, which alone gives a feeble greenish-yellow, gives with manganese a brilliant greenish-yellow color. Strontium sulphate, however, which fluoresces of a pale lilac color alone, has its color or intensity scarcely changed by the addition of manganese. Lead sulphate when alone gives a violet-blue feebly, which is changed by manganese to a beautiful yellow. Glucinum sulphate has the color of its fluorescence changed from green to yellowish-green. In all these cases the spectrum is a broad band reaching from wave-length 672–619 to 480–456, having a maximum at 600 to 550.

Bismuth sulphate, which alone does not fluoresce after calcination, gives to calcium sulphate, even in very small proportion, the property of emitting a beautiful red-orange fluorescence. To strontium sulphate it gives a still more brilliant fluorescence, of a tint somewhat less red. To barium sulphate, which alone does not fluoresce, a trace of bismuth oxide gives a fine orange-red fluorescence. To magnesium sulphate, bismuth oxide gives a red fluorescence, still less orange. No result was obtained with zinc, with cadmium or with lead sulphate. The spectrum bands extend over a considerable range in the spectrum and are characteristic.

Purified yttrium sulphate, which alone gives only traces of the yellow band $Z\alpha$ yields, when containing two per cent manganous sulphate, a fine yellow-green fluorescence whose spectrum consists of a wide band beginning nebulously at wave-length 650, reaching a maximum at about 564, having an appreciable intensity at 509–504, and ending vaguely at 489–484. A similar mixture with bismuth sulphate gives a beautiful red fluorescence, resolved by the spectroscope into a band beginning nebulously at 684, reaching a maximum at 642–640 and ending vaguely at 579–577. On treating calcium sulphate with manganous and with bismuth sulphates, with both of which it is active, the fluorescence was yellow at the center and pale green farther from the electrodes. The red-orange band was brighter than the green; but on heating the tube it almost disappeared. When cadmium sulphate was mixed with manganous and with bismuth sulphates, with the former of which only it fluoresces, the yellow-green light gave a spectrum somewhat more extended and less brilliant than that produced by manganese alone. When both zinc and calcium sulphates were mixed with manganous sulphate, in various pro-

portions, the green fluorescence of the calcium salt predominated when the weights of the two sulphates (zinc and calcium) were equal; while with equivalent weights the red of the zinc salt was slightly the stronger. This result increased with the proportion of the zinc sulphate until it became 98 per cent, the fluorescence being orange-red. On interrupting the current, the orange fluorescence quickly disappears, while the green of the calcium sulphate remains for a considerable time.

The author has also ascertained that calcined alumina does not give a trace of fluorescence when submitted to the electric discharge in vacuo. The characteristic fluorescence of this substance as described by Becquerel, who has figured its spectrum, is most brilliant when the alumina contains one per cent or even one-tenth of one per cent of chromic oxide. A very perceptible rose color is given by one hundred thousandth of chromic oxide. One per cent of manganous oxide yields a beautiful green, and the same quantity of bismuth oxide a lilac when cold and a blue on heating. Magnesia with one per cent of chromic oxide gives a fine red color; while lime does not appear to be affected by this oxide. The red fluorescence of alumina seems then to depend upon the presence of chromium; the analogy being complete between its action and that of manganese, bismuth, $Z\alpha$, $Z\beta$ and samarium.—*C. R.*, ciii, 468–471 (Sept.); 629–631 (Oct.); 1064–1067 (Nov.); 1107 (Dec.), 1886. G. F. B.

5. *On the Refractive index of Carbon dioxide and of Cyanogen.*—Chappuis and Rivière have deduced from their researches upon carbon dioxide at 21° and under pressures up to 19 atmospheres, and upon cyanogen at temperatures from 0° to 35° and pressures from 1 to 3 meters of mercury, formulas for calculating their refractive indices. They find for carbon dioxide at 0° and 0·76 meter, the value 1·000448, and for cyanogen under the same conditions 1·000825.—*C. R.*, ciii, 37–39, July, 1886. G. F. B.

6. *The Spectrum of Germanium.* — This spectrum has been mapped by H. Gustaf Kobb. It was formed by passing sparks from a large induction coil from an electrode of germanium to one of platinum. The lines of the latter could be readily identified and separated. The germanium lines are given in the following table:

λ	Observations.	$>$	
6336		5131	Broadly diffused.
6020	Very strong.	4813	" "
5892	"	4742	" "
5255·5		4684·5	Sharp. weak.
5228·5		4291	Diffused weak.
5209		4260·5	" "
5177·5	Broadly diffused.	4225·5	
5134		4178	" "

Ann. der Physik und Chemie, No. 12, 1886, p. 670. J. T.

7. *A new Quicksilver Pump.*—The three different systems of quicksilver pumps—the Geissler, the Töpler and the Sprengel—have their peculiar advantages and disadvantages. The Geissler

requires a large number of cocks; the Töpler is very fragile on account of the convolutions of its parts; and the Sprengel is suited only to certain kinds of work. Messrs. Greiner and Friedrichs describe a new pump which has a wide range of usefulness, with the possibility of obtaining a good vacuum. The chief peculiarity of the pump resides in a three-way cock, which is fully described in the author's paper. The use of but one cock gives the pump a great practical advantage.—*Ann. der Physik und Chemie*, No. 12, 1886, p. 672. J. T.

8. *Relation of the Electrostatic and Electromagnetic Units.*—The earlier determinations of this ratio by different investigators differ by as much as four per cent, and the later determinations of Exner (v=29,20.10^9), Klemencic (v=30,18.10^9) and J. J. Thomson (v=29,63.10^9), leave much to be desired. H. Hinstedt has made a new determination, and obtains the result v= 30,07.10^9. The method employed by Hinstedt required only the determination of the capacity of a condenser, Q, and a resistance, W, together with a ratio of resistances. The observations were independent of the electromotive force of the battery employed.—*Ann. der Physik und Chemie*, No. 12, 1886, pp. 560–579. J. T.

II. Geology and Mineralogy.

1. *Notes on the Geology of Northern California;* by J. S. Diller. (Abstract of paper, from the Proceedings of the Phil. Soc. of Washington, Jan. 16, 1886.)—Under the direction of Captain Dutton I have spent the last three summers studying the geology of northern California and the adjacent portion of Oregon. The conclusions of a general nature referring to that region may be briefly summarized as follows:

In the northern end of the Sierra Nevada and the central portion of the Coast range, among the highly plicated, more or less metamorphosed strata which are older than those of the Chico group, there appears to be but one horizon of limestone, and that is of Carboniferous age.

The northern end of the Sierra Nevada is made up of three tilted orographic blocks which are separated from each other by great faults. The westernmost of these blocks, stretching far to the southeast, appears to form the greater portion of the range. As in the Great Basin region, the depressed side of each block was occupied by a body of water of considerable size. The deposits formed in these lakes gave rise to the fertile soils of American and Indian valleys.

The *plication* of the strata in the Sierra Nevada range took place, at least in great part, about the close of the Jurassic or beginning of the Cretaceous period; but the faulting which really gave birth to the Sierra as a separate and distinct range by differentiating it from the great platform stretching eastward into the Great Basin region, did not take place until toward the close of the Tertiary or the beginning of the Quaternary. Although the

faulting may have commenced earlier, the greater portion of the displacement has taken place since the deposition of a large part of the auriferous gravels and the beginning of the great volcanic outbursts in the vicinity of Lassen's Peak. If we may accept numerous small earthquake shocks as evidence, the faulting still continues. The distribution of the rocks of the Chico group indicates that the western coast of the continent at that time lay along the western base of the Sierra, extending around the northern end of the range in the vicinity of Lassen's Peak and stretching far northeasterly into Oregon. Off the coast lay a large island which now forms northwestern California and the adjacent portion of Oregon. This island extended as far southeast as the Pit river region where it was separated from the main land by a wide strait. All of the ridges developed out of the Cretacean island belong to the Coast range.

The volcanic ridge of Lassen's Peak lies between the northern end of the Sierra Nevada and the Coast range. The great volcanic field of Oregon and Washington Territory, to which Lassen's Peak and the Cascade range belong, appears in a general way to be outlined by the depression between the Cretacean island and the main land. A general account of the facts from which these conclusions are drawn will appear in Bulletin of the U. S. Geological Survey No. 33.

2. *The Taconic System.*—In a paper read before the Philosophical Society of Washington, January 15th, 1887, entitled "Geologic Age of the Lowest Formations of Emmons's Taconic System," Mr. CHAS. D. WALCOTT considered: 1st. That he had found the fauna of the lowest formation of the original Taconic (the Granular Quartz) to belong to the Middle Cambrian or Georgia fauna. 2d. That the fauna of the typical "Upper" Taconic rocks in Washington County, N. Y., is a part of the same fauna. 3d. That the granular quartz and the Upper Taconic are the same geologic formation; the quartz rock being the shore deposit, and the shales, sandstones and limestones of the Upper Taconic being the synchronous deposit off shore, in deeper water. 4th, The hydromica shales beneath the limestone on the west side of the Taconic range are the equivalent of the Potsdam sandstone; the lower part of the limestone, or, in places, the hydromica shales between the quartz rock and limestone representing the Potsdam on the east side. 5th. Professor Dana was correct in considering the Stockbridge and sparry limestones and the overlying hydromica schists as of Lower Silurian (Ordovician) age; the latter representing the Hudson River formation. 6th. Of the strata referred to the Taconic system in the Taconic region, the granular quartz and the Upper Taconic still remain in it as pre-Potsdam formations, and the Stockbridge and sparry limestones and the superior hydromica schists are referred to the Lower Silurian (Ordovician) system.

Reference was made to the bearing of these generalizations on the use of the names Taconic and Cambrian; the former being

applicable to American strata carrying the first or primordial fauna unless Cambrian has a clear priority of usage.

Maps were exhibited to show the distribution of the formations under discussion in Vermont, Massachusetts and New York; and a section, crossing Washington County, N. Y., and into southern Vermont, gave the position of the formations in relation to each other. A hypothetical section, showing the formations as originally deposited, aided materially in the elucidation of the subject.

Specimens Hyolithes and Olenellus were shown from the "granular quartz" and the interbedded limestones of the Upper Taconic. C. D. W.

3. *Remarks on the Revision of the Palæocrinoidea of Wachsmuth and Springer;* by C. A. WHITE.—It has rarely happened that a more important paleontological work than this has been published; and it is still more rare that a difficult subject has been more philosophically treated. The work has been published in parts by the Philadelphia Academy of Natural Science, ending with the second section of Part III. Part I, embracing the families Ichthyocrinidæ and Cyathocrinidæ, was published in 1879. Part II, containing the Platycrinidæ, Actinocrinidæ and Rhodocrinidæ appeared in 1881. Part III, of which the second and concluding section has just been issued, gives the conclusion of the family and generic descriptions, a general review in which are suggested some modifications of the work of preceding parts, and an extended discussion of the classification and relations of the Brachiate Crinoids.

The authors have evidently aimed to bring into systematic order all existing knowledge of the paleozoic crinoids; and their work is therefore systematic rather than descriptive. The few new species which they have described are presented as illustrative of the general questions which they discuss.

They have from the beginning recognized the fact that the only way to arrive at a correct understanding of the fossil crinoids is by a comparative study of their living representatives. Therefore, the discussion of the morphological relations of the ancient and recent crinoids forms a conspicuous feature of their work. This method of treatment of the subject presents important zoological as well as paleontological results.

Even in the earlier part of the work these authors recognized two comprehensive types among crinoids, for which they established the orders Palæocrinoidea and Stomatocrinoidea; but for the latter they afterwards adopted the name Neocrinoidea, as subsequently proposed by Dr. P. H. Carpenter. The principal distinction between the two orders is found in the condition of the mouth and food grooves. In the Palæocrinoidea, these organs are more or less subtegminal, the food grooves along the disc taking the form of tubular passages, hidden beneath a vault; while in the Neocrinoidea the mouth and food grooves are open and exposed to view.

In their broader generalizations they recognize the stalked

echinoderms as constituting a class, for which they adopt Leuckart's appropriate name, Pelmatozoa, thus distinguishing them from Ophiurans, star-fishes and sea-urchins, which are characterized by locomotion and the downward position of the mouth. The Pelmatozoa are divided into two well-marked sub-classes, namely, the Crinoidea of Miller, embracing all brachiate crinoids, with the orders Neocrinoidea and Palæocrinoidea; and the Anthodiata, or armless forms, including the orders Blastoidea and Cystidea.

Three sub-orders are proposed, to include all the known forms of the Palæocrinoidea. (1) The Camarata, which are the typical Palæocrinoids, having the plates of the test solidly united by suture and having the lower armplates incorporated into the calyx by means of interradial plates. Actinocrinus is a typical form of this sub-order. (2) The Articulata, which are characterized by an articulate structure of the calcareous skeleton, which renders it more or less pliable, as in Ichthyocrinus. (3) The Inadunata, which have the arms free from the first radials upward, as in Cyathocrinus. These three groups are found to be also respectively characterized by differences in the construction of the summit, which the authors consider to be subordinate to and consequent upon the fundamental modifications in the plan of structure above mentioned.

The authors subdivide the Inadunata into two groups, namely, the Larviformia and the Fistulata. The former group includes such embryonic, or permanent larval, forms as Haplocrinus and Symbathocrinus. The latter group embraces forms which have the ventral portions of the body expanded or elevated into a porous ventral sac, of variable size, of which Cœliocrinus presents an extreme example.

The several groups are separated into many families, some of which are sharply defined, while others shade into each other by perplexing transitional forms. The generic relations of the Palæocrinoidea are minutely discussed, and a detailed diagnosis of each genus is given, which is followed by a list of all the species which the authors consider to be properly referable to the genus. The synonymy and references to the literature of each species is also given in full. At the end of the work is a complete catalogue of species, which serves both for an index and a synonymic list. This very valuable feature of works of this kind is too often entirely neglected by authors.

The morphological discussions in Part III deal with interesting questions in relation to homologies between different parts of the widely divergent types of recent and fossil crinoids. In the early larva of the living crinoids the abactinal side, so far as at present known, consists of only five basals, forming a cup. The actinal side consists of a closed pyramid of five plates; the latter covering the mouth. Subsequently the radials, and afterward the arms, appear. The appearance of the basals and orals at the same time, the one occupying the oral and the other the

aboral side, led Professor Goette and Mr. Wachsmuth independently to the conclusion that there exists a morphological resemblance between them. This view has since been accepted by Dr. Carpenter, and he, as well as Wachsmuth and Springer, base thereon the different views which they respectively entertain concerning the summit plates of the Palæocrinoidea.

The orals in most of the recent crinoids are confined to their larval state, but whether they are persistent through life, or are resorbed in the adult, the mouth and food grooves become exposed to view before the animal reaches maturity. In the Palæocrinoidea these organs are permanently closed by series of plates which collectively occupy the place of the orals in the Neocrinoid larva. The authors of the revision agree with Dr. Carpenter upon this point; but they differ from him as to which of the various summit plates in the Palæocrinoidea individually represent the orals.

The authors have ascertained that the summit and other vault plates, which were generally ignored by the earlier writers, have a high classificatory value. They find them to be arranged upon a well-defined general plan which, to a considerable extent, should be regarded as a counterpart of that which is shown by the plates of the calyx. The plan consists of a central piece, which occupies the oral pole and covers the mouth, six proximal plates surrounding this central one, but they are not always in contact with it, and frequently radial dome plates, corresponding with the calyx radials. The authors conclude that the central piece of the dome, which they think primitively consisted of five pieces, is the homologue of the basals, and that it represents morphologically the closed pyramid of five oral plates in the Neocrinoid larva, the proximals representing the calyx interradials. Contrary to this Dr. Carpenter believes that the orals are represented by the six proximals surrounding the central piece, the two smaller posterior ones being regarded by him as one plate divided by anal structures. This view was formerly held by Wachsmuth and Springer, but they have since abandoned it. Dr. Carpenter regards the central piece as representing the dorso-central or terminal plate of the column. Both parties support their opinion by extended arguments based on the latest researches upon both recent and fossil crinoids, with an earnestness which shows their full conviction of the correctness of their respective opinions.

An important discovery is announced as to the relations of the parts on the dorsal side of the paleozoic crinoids which seems to be of much importance in their practical study; and a statement of it will serve to illustrate the minute care with which these authors have prosecuted their work. They consider the first ring of plates below the radials as the true basals in all cases. In those crinoids which have a dicyclic base the lower ring of plates are called the underbasals. These are often very minute, concealed within the basal concavity, or hidden from external view

by the column, so as to be difficult, and in many cases impossible, to distinguish.

By cutting, grinding and breaking many specimens, Wachsmuth and Springer have discovered that there is a regular alternation in the arrangement of the successive parts below the radials. The basals are interradial in position and all underbasals are radial. The exterior angles of the column, if it be angular, alternate with the ring of plates next above it; and if the central canal in the column be angular, its angles alternate with those of the column. So, if in relation to the calyx plates above, the exterior angles of the column are found to be radial in position, the ring of plates next above, being alternately arranged, will be basals, and consequently underbasals are wanting. If, on the contrary, those angles are interradial, the next plates in succession above will be radial, and hence underbasals. If the column be round, and the axial canal angular, the angles of the latter may be consulted; if radial, underbasals are present; if interradial, they are absent. Similar results are given by the cyrri when they exist; and by the segments of the column, when divided longitudinally, as sometimes happens.

It thus becomes possible to distinguish between underbasals and the top segment of the column, which has hitherto been often attended with difficulty. The authors assert that this rule is applicable without an exception to the paleozoic crinoids.

An appendix to the work contains two articles. In the first the authors place the genus Stephanocrinus among the Palæocrinoidea, assigning it to the Larviformia. Roemer and J. Muller had previously referred this genus to the Cystidea; and later, Etheridge and Carpenter referred it to the Blastoidea. The latter authors seem to have regarded the evidence adduced by Wachsmuth and Springer as conclusive, for in their lately-published catalogue of the Blastoidea they omit Stephanocrinus.

In the second article they apply the rules which they have found to govern the structure of dicyclic and monocyclic Palæocrinoidea, to the later crinoids; and they come to the conclusion that the Apiocrinoidæ and Comatulæ are constructed upon the plan of dicyclic crinoids; and that in their larval state they probably had rudimentary underbasals. If hereafter those plates should be discovered their existence will have been predicted upon paleontological evidence, and as the result of comparative studies.

The second section of Part III completes the work as the authors originally planned it; but they have begun the preparation of a monograph of the Paleozoic Crinoids of North America, which they intend to make the most extensive illustrated work on crinoids ever produced. Paleontologists will await the results of their newly self-imposed task with great interest. C. A. W.

4. *A card to American Geologists.*—A meeting of the American Committee of the International Congress of Geologists, will be held in Albany from April 6 to April 9, 1887.

The object of the meeting is to perfect a scheme embodying the thoughts of American geologists on the questions of classification, nomenclature, coloration, etc., entering into the system of unification of geological science which is the object of the International Congress. In order that the Committee may represent the views of all American geologists it invites from all their individual opinions on any subjects likely to arise in the Congress. Those who will meet the American Committee in Albany, are requested to send to the undersigned a note of the topic or topics they propose to treat, and the time which they will require. In cases where it is not convenient for them to go to Albany, they are requested to forward a statement of their views in writing to the undersigned before April 1, for presentation to the Committee. For information as to the kinds of questions to be discussed, attention is called to the report of the American Committee published last Spring, in which the debates of the 3d session of the International Congress are reported. The following are the sub-committees of the American Committee:

Archæan, Hunt, Hitchcock, Winchell; *Lower Paleozoic*, Hall, Winchell, Lesley; *Upper Paleozoic*, Hall, Lesley, Newberry, Stevenson, Williams; *Mesozoic*, Newberry, Cook, Cope, Powell; *Cœnozoic* (Marine,) Smith, Newberry; *Cœnozoic* (Interior), Cope; *Quaternary*, *Recent Archæology*, Powell, Winchell, Cook.

PERSIFOR FRAZER, *Secretary.*

5. *The "Mountain limestone" in Pennsylvania a little over 1100 feet below the Pittsburg Coal.*—The Pennsylvania Geological Report for the year 1885, contains, on pages 222 to 226, a brief report, by Professor A. Linn and E. Linton, on the discovery of the Mountain limestone in connection with the Washington County gas well. The limestone is nearly pure for 120 feet or so, and has below it 60 feet of arenaceous limestone. The latter contains quartz sand, and even pebbles in places, with some grains of feldspar. This bed is regarded as the equivalent of that described by Professor Lesley and Dr. Stevenson as occurring in the gaps of Laurel Hill and Chestnut Ridge.

6. *Fossil Trunk of a tree in hydromica or sericitic gneiss.*—Dr. E. de Fellenburg announced to the Helvetic Society of Natural Sciences in Geneva, Aug. 1886, the discovery of a fossil trunk of a tree in the gneiss of the valley of Oberhasle (Haslithal) —the length 1·45 meter, and breadth 0·12 to 0·17. It is not quite cylindrical, and has a series of annular furrows, in several places a brown coating, with fine longitudinal striations and what appears to be a series of joints. Another smaller specimen accompanied this; some characters suggested that it was a Calamites, but no decisive opinion is expressed. Professor Baltzer stated further that the sericitic gneiss is associated with phyllite, and also with bands of granite; and he expressed his confidence that the specimen was a true fossil, and the gneiss a paleozoic gneiss.—*Arch. Sci. Phys. et Nat. Geneva*, Sept.–Oct., 1886.

7. *Second Contribution to the Studies of the Cambrian*

Faunas of North America; by C. D. WALCOTT. 369 pp. 8vo, with 33 plates. Washington, 1886. Bulletin No. 30, U. S. Geol. Survey. A very large and elaborate contribution to Cambrian Paleontology, with numerous excellent illustrations on the 33 plates.

8. *The Geological and Natural History Survey of Minnesota for* 1885. N. H. WINCHELL, State Geologist.—This volume contains reports on the Aphididæ of the State by O. W. Œstlund, on Cheiocrinus and Calceocrinus and some new genera of Crinoids by E. O. Ulrich; Report on the Museum; bibliography in the department of Foraminifera; new fossils by N. H. Winchell; on copper alloyed with silver from the L. Superior region (less than one-tenth per cent in assays given), and on the Cambrian of Minnesota, by the same.

9. *Annuaire Géologique universel et Guide du Géologue autour de la Terre, etc.*, publié par le Dr. Agincourt avec le concours de nombreux Géologues, E. Chelot Secrétaire. Tome II, 1e partie, 362 pp.; 2e, Appendice, 27 pp.; 3e, Index bibl. 1885, 79 pp. Paris, 1886.—This second edition of the Geological Annual by Dr. Agincourt is an important advance upon the volume of last year both as regards amount of matter and accuracy. It includes a long list of the Geologists of different countries, with their addresses; of the prominent museums; geological charts and other kindred matter.

10. *Notes on Minerals from North Carolina;* by G. VOM RATH. —In a recent copy of his "Vorträge und Mittheilungen," containing the communications made to the Scientific Society at Bonn between the dates January 11 and July 7, 1886, Professor vom Rath gives, together with other interesting matter, the results of his study of some North Carolina minerals. The specimens in hand were received from Mr. W. E. Hidden, having been found by the latter in his explorations in the neighborhood of Stony Point, Alexander County. The following abstract includes the points of most interest.

BERYL.—A highly modified crystal 12^{mm} in length by 10^{mm} in width, and of nearly ideal symmetry, was found to be a combination of the following forms:

$O\,(0001)$, $I\,(10\bar{1}0)$, $i\text{-}2\,(11\bar{2}0)$, $1\,(10\bar{1}1)$, $2\,(20\bar{2}1)$, $2\text{-}2\,(11\bar{2}1)$, $3\text{-}\frac{3}{2}\,(21\bar{3}1)$, $4\text{-}\frac{4}{3}\,(31\bar{4}1)$, $2\text{-}\frac{3}{2}\,(42\bar{6}3)$, $6\text{-}\frac{3}{2}\,(42\bar{6}1)$, $\frac{3}{4}\text{-}\frac{3}{8}\,(54\bar{9}4)$? $\frac{3}{2}\text{-}\frac{3}{2}\,(21\bar{3}2)$.

The figure accompanying the description shows all these planes except the last two. The form $4\text{-}\frac{4}{3}$ is spoken of as new to the species, which, however, is hardly true, as it was noted by Hessenberg in 1863 on an Elba crystal. The results of careful measurements agreed very closely with the angles given by Kokscharow as seen in the following list; the double angles indicate the extreme values for the different edges measured.

Vom Rath.	Kokscharow.
$O \wedge 2\text{-}2 = 135°\ 2'$ to $135°\ 4'$	$135°\ 3'\ 55''$
$2\text{-}2 \wedge 2\text{-}2 = 138°\ 37'$ to $138°\ 38\frac{1}{2}'$	$138°\ 38'\ 23''$
$O \wedge 1 = 150°\ 1'$ to $150°\ 3'$	$150°\ 3'\ 24''$
$1 \wedge 1 = 151°\ 4'$ to $151°\ 6\frac{1}{2}'$	$151°\ 5'\ 45''$

It was observed that the fine emerald color characteristic of the crystal under examination belonged to a border $\frac{1}{2}$ to $\frac{3}{4}$mm in thickness; furthermore, narrow canals hexagonal in form and made by planes of the unit prism, were noted running through the crystal parallel to the vertical axis.

Monazite.—The crystals examined were remarkable for their size and perfection of form, and especially interesting as being penetration-twins cruciform in shape, with the orthopinacoid as the twinning plane. The chief points in regard to these crystals are contained in the note by Mr. Hidden in this Journal for September last, p. 207. In addition to the planes given by Hidden, vom Rath notes 1-2 ($\bar{2}12$). As fundamental angles were taken $001 \wedge 1\text{-}\dot{1} = 138° 7'$, $010 \wedge 110 = 133° 8'$, also the twinning angle $1\text{-}\dot{1} \wedge 1\text{-}\dot{1} = 160° 4'$; from these the axes were calculated

$$\dot{a} : b : \dot{c} = 0{\cdot}96092 : 1 : 0{\cdot}90807 ; \ \beta = 103° 26\tfrac{1}{4}'.$$

The faces did not allow, in most cases, of very accurate measurements, though on the whole the agreement with the calculated angles was tolerably satisfactory. A minute comparison is made with the crystals from other localities both as to occurring planes and angles. Some of the measured and calculated angles are:

	Measured.	Calculated.	Measured.	Calculated.
$i\text{-}i \wedge O$	103° 29′	103° 26¼′	$1\text{-}\dot{1} \wedge 2\text{-}\dot{1} = 160° 1'$	160° 25¾′
$i\text{-}i \wedge 1\text{-}\dot{1}$	100° 23′	99° 58′	$1\text{-}\dot{1} \wedge 1\text{-}i \wedge 119° 26'$	118° 48¼′
$i\text{-}\dot{1} \wedge 1\text{-}\dot{1}$	131° 53′ 132° 5′ 130° 40′	131° 53′	$I \wedge 2\text{-}\dot{1} = 133° 4'$ $i\text{-}\dot{1} \wedge 2\text{-}\dot{1} = 150° 40'$	132° 54¾′ 151° 27¼′

Apatite.—Some delicate prismatic crystals (25mm in length) showed the planes $O(0001)$, $\frac{1}{2}(10\bar{1}2)$, $1(10\bar{1}1)$, $2(20\bar{2}1)$, $1\text{-}2(11\bar{2}2)$, $2\text{-}2(11\bar{2}1)$, $3\text{-}\frac{3}{2}(21\bar{3}1)$. The angles measured agreed within a minute or two with those of Kokscharow.

Spodumene.—Some crystals, 20mm in size, and fully developed at both ends except a single point of attachment, proved to be very different in habit from the hiddenite previously described. The identification of the planes was a matter of some difficulty, as the faces were dull and only to be measured by means of attached glass plates. The planes observed are given in the following list; of these, *z*, *f*, *t*, *d*, and φ are new.

$b(010, \dot{i}\text{-}\dot{1})$; $I(110)$, $m(120, \dot{i}\text{-}\dot{2})$, $n(130, \dot{i}\text{-}\dot{3})$, $z(150, \dot{i}\text{-}\dot{5})$; $f(011, 1\text{-}\dot{i})$; $\phi(312, \frac{3}{2}\text{-}3)$, $d(\bar{4}21, 4\text{-}2)$, $e(\bar{2}41, 4\text{-}\dot{2})$, $t(\bar{4}81, 8\text{-}\dot{2})$.

As fundamental angles were taken:

$$I \wedge I' = 86° 48', \ I \wedge e = 147° 30', \ b \wedge e = 152° 45',$$

and the axial ratio calculated is

$$\dot{a} : \dot{b} : \dot{c} = 1{\cdot}1283 : 1 : 0{\cdot}62345, \ \beta = 110° 27\tfrac{1}{2}'.$$

These results agree very well with the axial ratio given by J. D. Dana for the Norwich crystals. The crystals showed *f* and φ large and striated parallel to the edge of *I* and *f*; *I*, *b*, *t* were also well developed, while the other planes were quite small.

Another spodumene crystal, prismatic in habit and 18^{mm} long, resembled in aspect crystals of certain varieties of pyroxene. The crystal was altered and the faces consequently were dull and gave poor measurements. The planes finally identified were

a(100, i-i), b(010, i-$\bar{i}$), I(110), m(120, i-2), k(230, i-$\frac{3}{2}$), h(021, 2-$\bar{i}$), e(241, $-$4-$\bar{2}$), ξ(131, $-$3-$\bar{3}$), x($\bar{2}$31, 3-$\frac{3}{2}$), w($\bar{3}$21, 3-$\frac{3}{2}$), v($\bar{3}$41, 4-$\frac{4}{3}$).

Of these, k, ξ, w and v were new to the species.

RUTILE.—The beauty and brilliancy of the black rutiles is strongly emphasized by vom Rath. The most remarkable crystal was a combination of the planes: i-i(100), I(110), i-$\frac{5}{3}$(530), i-$\frac{9}{4}$(940), i-4(410), 1-i(101), 1(111), 321(3-$\frac{3}{2}$); of these the prism i-$\frac{9}{4}$ is new. The crystal was a twin of the rare type figured by Miller in his Mineralogy, the twinning-plane being 3-i.

TOURMALINE.—Three crystals examined were 14 to 16^{mm} in length and 7 to 10^{mm} through the prism. They showed the two prisms, and the terminating planes R(10$\bar{1}$1), $-\frac{1}{2}R$(01$\bar{1}$2), $-2R$ (01$\bar{1}$2), $-2R$(02$\bar{2}$1), in one crystal the form $-\frac{1}{2}R$ was prominent; the planes $\frac{2}{3}$-2(11$\bar{2}$3) were also identified.

XENOTIME.—A few remarks are made in regard to some crystals already described more fully by Mr. Hidden. The terminal angle of the pyramid was found to be 124° 28′ and 124° 30′.

11. *Notes on Aquamarine from Mount Antero, Colorado;* by Rev. R. T. CROSS. (Communicated.)—The aqua-marines forming the subject of this note were obtained two or three years ago on Mt. Antero, in Chaffee County, Colorado, by Mr. N. D. Wanamaker. He states that they were found in the decomposed granite of the Sawatch Range, Continental Divide, above timber line, and most of them near together in one pocket. I have deferred writing this note in the hope of being able to visit the locality myself, but in this I have been disappointed.

The color of the aqua-marines is bluish green. The two largest crystals found were three inches long and about half an inch in thickness. Of those now in my possession eight crystals have terminations, and a dozen others are tolerably clear but not terminated. The longest crystal is one and three-eighths inches in length and three-eighths of an inch in diameter. The lower third is translucent, the remainder transparent, with some flaws. This crystal, like the others, is finely striated on the prism, but the basal plane is very smooth and brilliant. The next crystal is very nearly the same size, is clear through its whole length, but has only an imperfect termination. Another is three-fourths of an inch long, and on its termination shows the planes 2-2 quite large, and the planes 1 and 2 very small. The terminal edges of the prism of a number of the crystals are rounded; and some of them exhibit what appear to be slender longitudinal cavities running parallel to the prism, and probably due to striations on the original crystal now forming the core. This central part, or core, is often very distinct; it is transparent, while the outside layer, looked at lengthwise, is opaque. Sometimes the core projects at

the broken end of the crystal in a globular form, similar to certain tourmalines described by Hamlin.

On examining the crystals closely I found a few which had attached to them what seemed to be small quartz crystals. The angles, however, did not appear to agree with those of quartz, and knowing that phenacite was often mistaken for quartz, as its name suggests, I thought that they might be phenacites. Mr. W. Cross confirmed my supposition, and he placed the crystals in the hands of Mr. Penfield of the Sheffield Scientific School, who has fully described them (see page 130 of this number).

III. Botany and Zoology.

1. *Beobachtungen über den Blumenbesuch von Insecten und Frielandpflanzen des Botanischen Gartens zu Berlin.* von Dr. E. Loew, Oberlehrer am K. Realgymnasium zu Berlin, 1885. Also *Weitere Beobachtungen*, etc., 1886.—These two papers, published one in the third, the other in the fourth volume of the *Jahrbuch* of the Berlin Botanic Gardens, together make a treatise of 180 pages, intended to supplement and to extend the well-known investigations of the late Hermann Müller upon the reciprocal relations of showy flowers and insects. Müller investigated these relations in a natural flora, that of Germany, in which these relations were normally established. Dr. Loew studies them in an artificial assemblage of plants recently brought together in a large botanical garden. Müller undertook, by counting the visitors to each kind of flower, to determine what kinds and species of insects were especially active in its fertilization, and how the insect had become adapted to the particular blossom, as well as the blossom to the insect, in the long process of natural selection. Dr. Loew's object was to ascertain what selections each species or group of insects will make among the flowers of all the principal natural orders brought together for cultivation in our own days from various parts of the world. To keep the inquiry within definite and manageable limits, it was restricted to three geographical groups of plants: 1, those of the European and N. Asiatic forest zone; 2, those of the Mediterranean and the Orient; 3, N. American and E. Asiatic plants.

Müller assumed that wherever the flower and its fertilizing insects harmonize perfectly in their adaptations, it must be that the visiting insects have remained the same since the blossom, under the influence of the fertilizers, acquired its special adaptations; and that, wherever the adjustment is incomplete a considerable change has occurred; either the plant is an immigrant from some other locality, or foreign insects have come into its locality, or its proper cross-fertilizers have disappeared. And the conclusions gathered from Müller's statistics were: 1. That the more exposed the nectar in a flower, the larger the proportion of insects with short proboscis visiting it, also, of the kinds; while in proportion as the nectar is removed from direct access, the pro-

portion of visitors with long proboscis increases, bees, flies and butterflies; 2. Conversely it is found that the shorter the proboscis of an insect the more it visits flowers with free or little concealed nectar; the longer the proboscis the more it prefers flowers with deep-seated nectaries. And insects specially adapted to flowers of a particular form mainly visit these flowers only. 3. Short-lipped insects prefer light-colored blossoms (white and yellow); those with long proboscis, not in need of much food, prefer deep colors (red, blue, violet); but those which require more nourishment are not so particular as to color.

The question which Loew asked was, whether these conclusions hold good of foreign plants placed before the insects of a certain locality. On the whole, they were corroborated by his very extensive observations in the Berlin Garden. But the selection of foreign plants by the bee tribe was often different from that of indigenous plants. For example, among the fitting S. European and Oriental flowers presented to them in the garden, bees and humble bees greatly preferred deep-colored flowers; while among the American plants the lighter-colored Compositæ were preferred, probably because the number of the yellow-flowered Compositæ was so greatly in excess of the proper bee-adapted flowers. Moreover, some nearly related genera of the bee-tribe, and with proboscs of the same length, differed greatly in their selection of flowers; indeed, in most *Apidæ* the selection of flowers was evidently much influenced and even determined by some other factor than the mere length of the proboscis. From such facts Loew is led to believe that Müller's theory of the origination of long-beaked *Apidæ* from the short-beaked, in a direct line through natural selection *pari passu* with corresponding change in flowers, is not borne out. Müller had concluded that Compositæ-flowers were a sort of common feeding-ground of various classes of insects; and the way in which bees and other indigenous insects shifted their preferences to foreign *Compositæ* in the Berlin garden confirmed this. Finally, Loew proposes a more simple classification than Müller's of the stages or adaptation of insects to flowers, based upon morphological and biological characters, quite irrespective of theories of descent, rightly keeping the latter in abeyance until the facts are determined by direct observations. A. G.

2. Minor Botanical Notes. — Under the patronage of the Bentham Trustees, volumes xvi and xvii, of *Hooker's Icones Plantarum*, have been simultaneously in press during the past year. The two parts of the sixteenth volume, wholly phanerogamous, have already been noticed. Of vol. xvii, which is wholly devoted to Ferns under the editorship of Mr. Baker, three parts have appeared. One of them gives a figure of a new North American Fern, the *Asplenium Glenniei* of Baker (*Athyrium gracile* of Fournier), a Mexican species, which Mr. and Mrs. Lemmon collected in the mountains of S. Arizona.

Baron von Müller, Government Botanist for Victoria, Australia, has just brought out, under official auspices, his *Descrip-*

tion and Illustrations of the Myoporineous Plants of Australia, i. e. the lithograms, seventy-four plates, in a beautiful large quarto volume. The letter press is to come "somewhat later." But that, as the author intimates, can wait, because the species here so admirably illustrated are all described either in the monumental *Flora Australiensis* (which owes its value no less to Müller's labors than to Bentham's), or in the *Fragmenta Phytogr. Australiæ*, a part of the special and multitudinous work of the present author. There was a natural wish to give colored plates, which would have cost very much more, but would have been not much better for truly botanical purposes. The drawings are all by R. Graff, and are his first effort in this line. They are truly good, and the lithography does credit to the Government printing office at Melbourne, and to the Colony.

The Report on the Primula Conference held at South Kensington, April 20, 21, 1886, and on the *Orchid Nomenclature Conference held at Liverpool*, on June 30, 1886, makes up vol. vii, no. 2, of the *Journal of the Royal Horticultural Society*, London. The most permanently interesting matter is the part relating to the origin and history of the cultivated Auricula, and next Dr. Masters' paper on the root-structure and mode of growth of Primulas, with copious illustrations. As to Orchid Nomenclature for the mass of varieties and forms in cultivation, the upshot of the conference seems to be, that the botanists should give scientific names to the more distinct forms, and the cultivators should not imitate those, but give fancy names—vernacular or other, but never Latin—to their own productions and to indicate those differences which the grower may value, but the botanist takes no account of.

Professor Macoun's *Catalogue of Canadian Plants*, part iii, *Apetalæ*, has just appeared, although the preface is dated April, 1886, since which, we presume, it was printed. It is one of the publications of the Geological and Natural History Survey of Canada. This completes the first volume, carrying it on from p. 305 to p. 623, including an elaborate appendix to the first and second parts, and a complete index to the volume. This volume embodies a vast amount of work, both in field and in herbaria, and is full of valuable observations. Our attention is particularly arrested by the observations on trees, especially the coniferous trees, which naturally are most important as well as interesting. A. G.

3. Botanical Necrology for 1886. — The following are European:

Eduard Morren, Professor of Botany and Director of the Botanical Institute at Liège, Belgium, son of a distinguished botanist, himself more distinguished, died at Liège, February 28, at the age of 53 years.

Rev. Wm. W. Newbould, a most acute and critical British botanist, died at Kew, April 16, at the age of 67.

Dr. Wm. Hillebrand, who lived and botanized for several

years in the Sandwich Islands, had published not a little upon their botany, and was engaged upon a Flora Hawaiensis, died, at Heidelberg, July 13. He is commemorated by the Begoniaceous genus *Hillebrandia* of Oliver.

Dr. Henry Fletcher Hance, English Consul at Whampoa, an acute and most indefatigable systematic botanist, unequalled for his knowledge of Chinese botany, died at Hongkong, June 22, at the age of 59. Mr. Francis B. Forbes, equally a devotee to Chinese botany, contributes to the Journal of Botany, British and Foreign, for January, 1886, an appreciative memoir of his associate and friend.

T. G. Orphanides, Emeritus Professor of Botany in the University of Athens, and who in former years did much to make the botany of Greece better known by excellent *Exsiccatæ*, died August 17, at the age of 69.

Prof. J. W. Albert Wigand, of the University of Marburg, after a long illness, died at Marburg, October 22, in the 66th year of his age.

The notable loss from our ranks in this country is that of our eminent Lichenologist,

Edward Tuckerman, who died on the 15th of March last, in the 69th year of his age. His biography is given in this Journal, vol. xxxii, and in the Proceedings of the American Academy of Arts and Sciences, vol. xxi, 1886. A. G.

4. *Bulletin of the Museum of Comparative Zoology*, Harvard College.—No. 6, vol. xii, on the Deep Sea Mollusca, (Brachiopoda and Pelecypoda,) by W. H. Dall, from dredgings of the steamer "Blake." No. 1, vol. xiii, on the Holothurioidea, ibid., by H. Théel.

5. *Elementary Course in Practical Zoology;* by Buel P. Colton. 186 pp. 12mo. Boston, 1886 (D. C. Heath & Co.)—This small manual for practical zoology covers the whole animal kingdom in a concise manner, and will be found a convenient work for the student.

IV. Miscellaneous Scientific Intelligence.

1. *Ice Period in the Altai Mountains.*—Mr. E. Michaelis, in *Nature* of December 16 (p. 149) states that in the southern part of the Altai, where there are now some large glaciers, there are evidences of "a mighty spreading of ancient glaciers." The evidences occur to the south on the ranges of Tarbagatay and Savor, the southern limits of the basin of the Irtysch, where there are now no glaciers. There are great bowlder and cobblestone deposits on the northern slopes, extending for ten miles from south to north. The Savor chain is a post-Tertiary elevation; the Altai is of remote age, and must have formed dry land since the Cretaceous period at least.

2. *Signal Service Bureau.*—The death of the head of this bureau, General Hazen, opens the question as to the best successor. The work of the bureau is scientific in the collection of

facts and the preparation of daily reports on the observations, as well as in the discussion of the series of results brought in from over the country and world with reference to a knowledge of meteorological principles, and a broad basis for prognostications. All considerations sustain the decision that the head of the department should be a man of meteorological and physical science, accustomed to scientific work, and, at the same time, one of large executive experience and success.

G. F. Matthew. Fauna of the St. John Group, No. 3, Trans. Roy. Soc. Can., 1885.

Bulletin of the Washburn College Laboratory, Topeka, Kansas, vol i, No. 7. Contains descriptions of fresh-water molluska by R. E. Call and notes on fishes by C. H. Gilbert.

Bulletin of the Buffalo Soc. Nat. Sci., vol. v, No. 2. Contains papers on the fossil fishes of the Genesee, Portage and Black Shales, by H. U. Williams; and on the fishes of the Corniferous, by the same and F. K. Mixer, and other papers.

Catalogue of Fossil Mammalia of the British Museum, Part 3, by R. Lyddekker. Contains catalogue with notes of the Ungulate, suborders Perissodactyla, Taxodontia, Condylarthra and Amblypoda, with some figures.

The Geology of Long Island, by F. J. H. Merrill, 24 pp. 8vo, with 2 plates (Ann. N. Y. Acad. Sci., iii, Nos. 11, 12, 1886). A valuable contribution to American geology.

Fossil Insects.—Bulletin No. 31 of the U. S. Geological Survey contains a systematic review of our present knowledge of Fossil Insects, including Myriapoda and Arachnids, by Mr. S. H. Scudder.

OBITUARY.

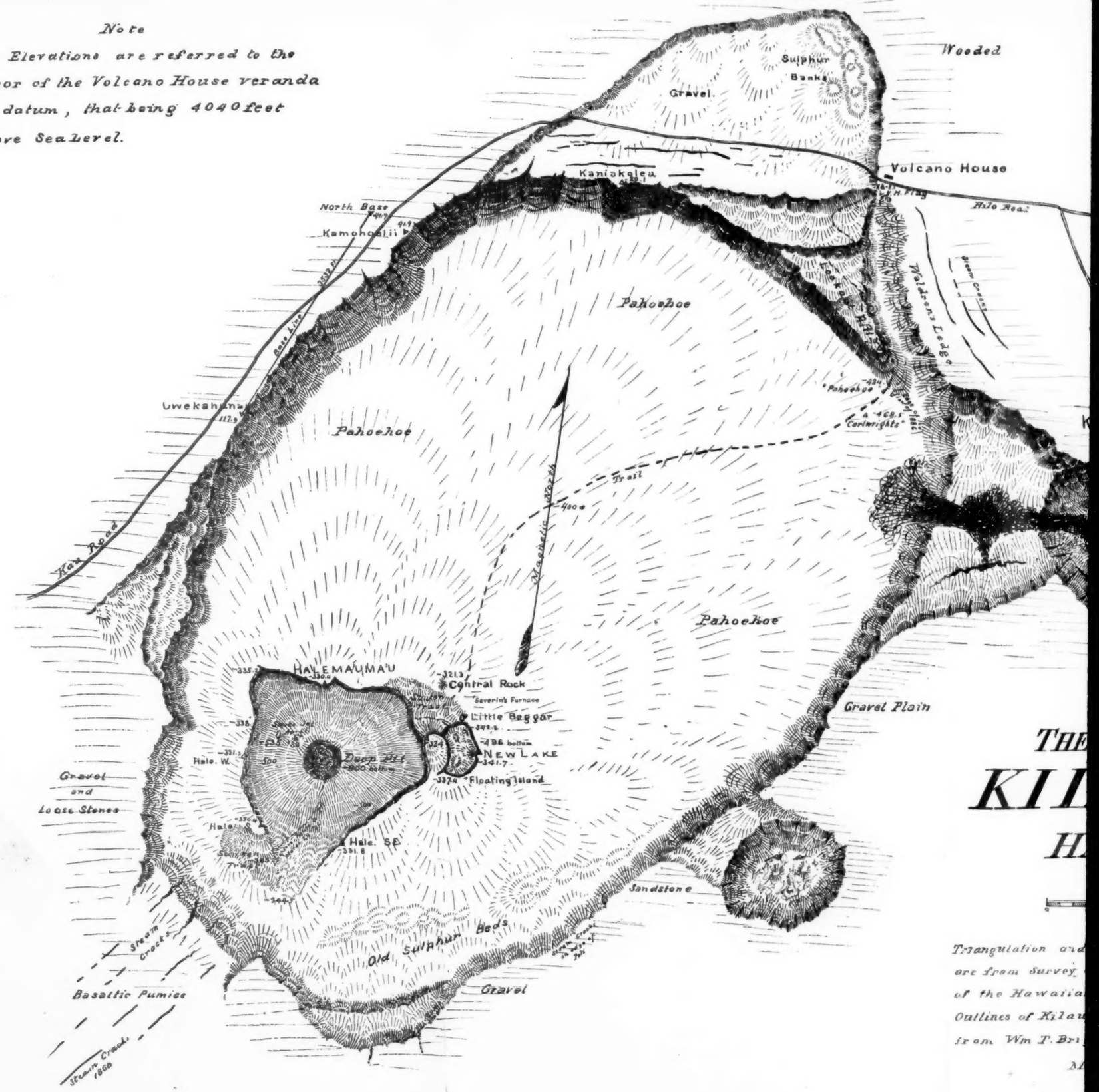
Professor E. L. YOUMANS, of New York, died on the eighteenth of January, in his 67th year. He had long been active and successful in the work of extending a knowledge of scientific truths and principles among the general public. His published works include a Class Book of Chemistry (1852); Alcohol and the Constitution of Man (1853); Chemical Atlas (1855); Hand-book of Household Science (1857); and some others. He planned the well known International Scientific Series, begun in 1871 and of which fifty-seven volumes have now been issued. He also established the Popular Science Monthly in 1872, of which he remained the chief editor. A compilation of essays on the Conservation of Energy and the Correlation of Forces, to which he added an Introduction, was prepared by him in 1864. He was also instrumental in extending a knowledge of the writings of Spencer, Tyndall and Huxley in this country, and as the scientific adviser of the Messrs. Appleton, and in other ways, his influence was felt in the advancement of science.

SELWYN L. HARDING, the young author of a valuable paper in the first number of this volume died early in January after five days illness. The past summer he received from Harvard his degree of A.B., *summa cum laude*, with honors in physics; and at the time of his death he was studying Electrical and Mechanical Engineering in the Massachusetts School of Technology.

THEODOR VON OPPOLZER, the eminent astronomer, died at Vienna on the 26th of December in his 46th year.

Note

All Elevations are referred to the floor of the Volcano House veranda as datum, that being 4040 feet above Sea Level.



THE
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Triangulation and
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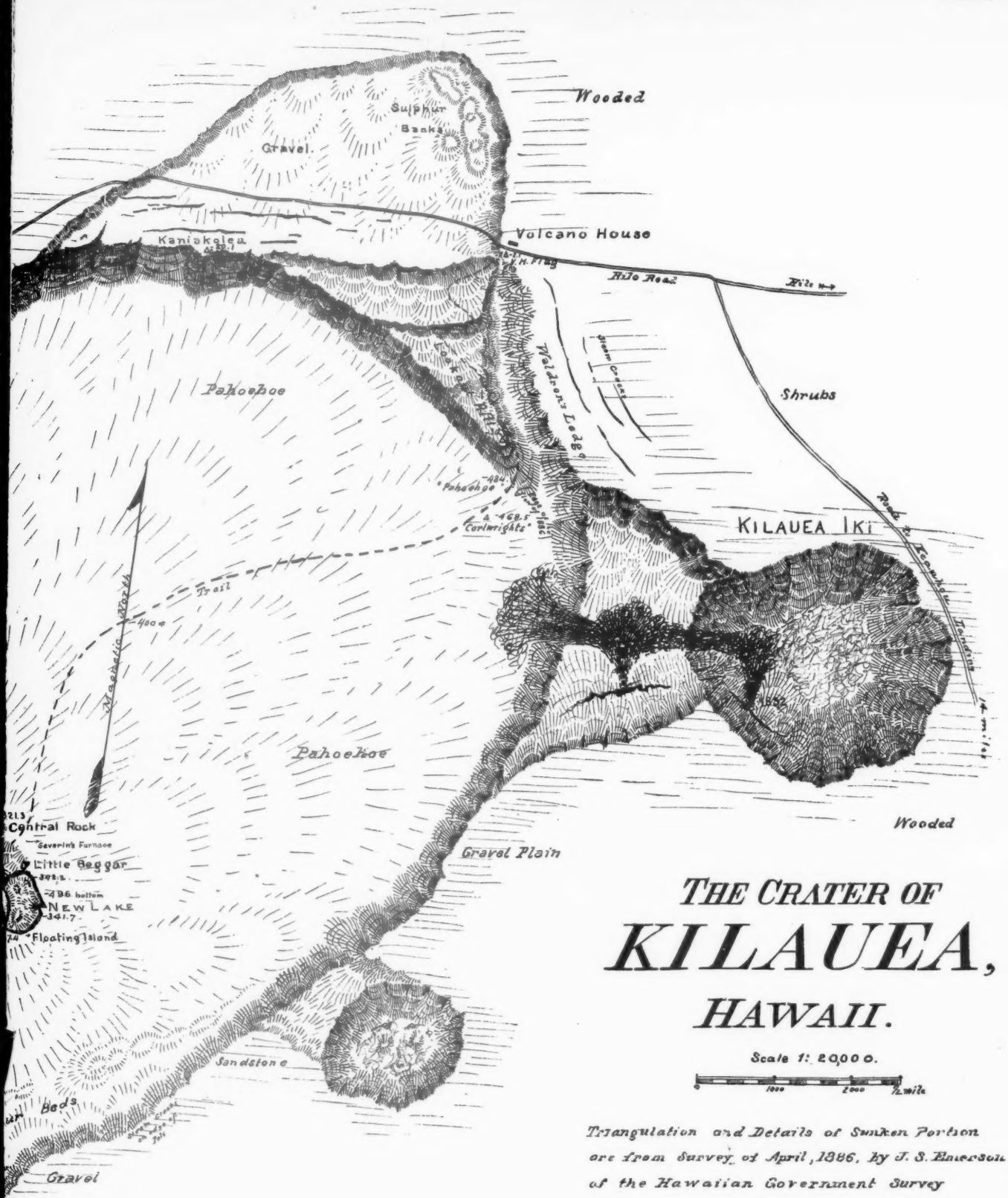
of the Hawaiia
Outlines of Kilau
from Wm T. Bri
M



THE CRATER OF KILAUEA, HAWAII.

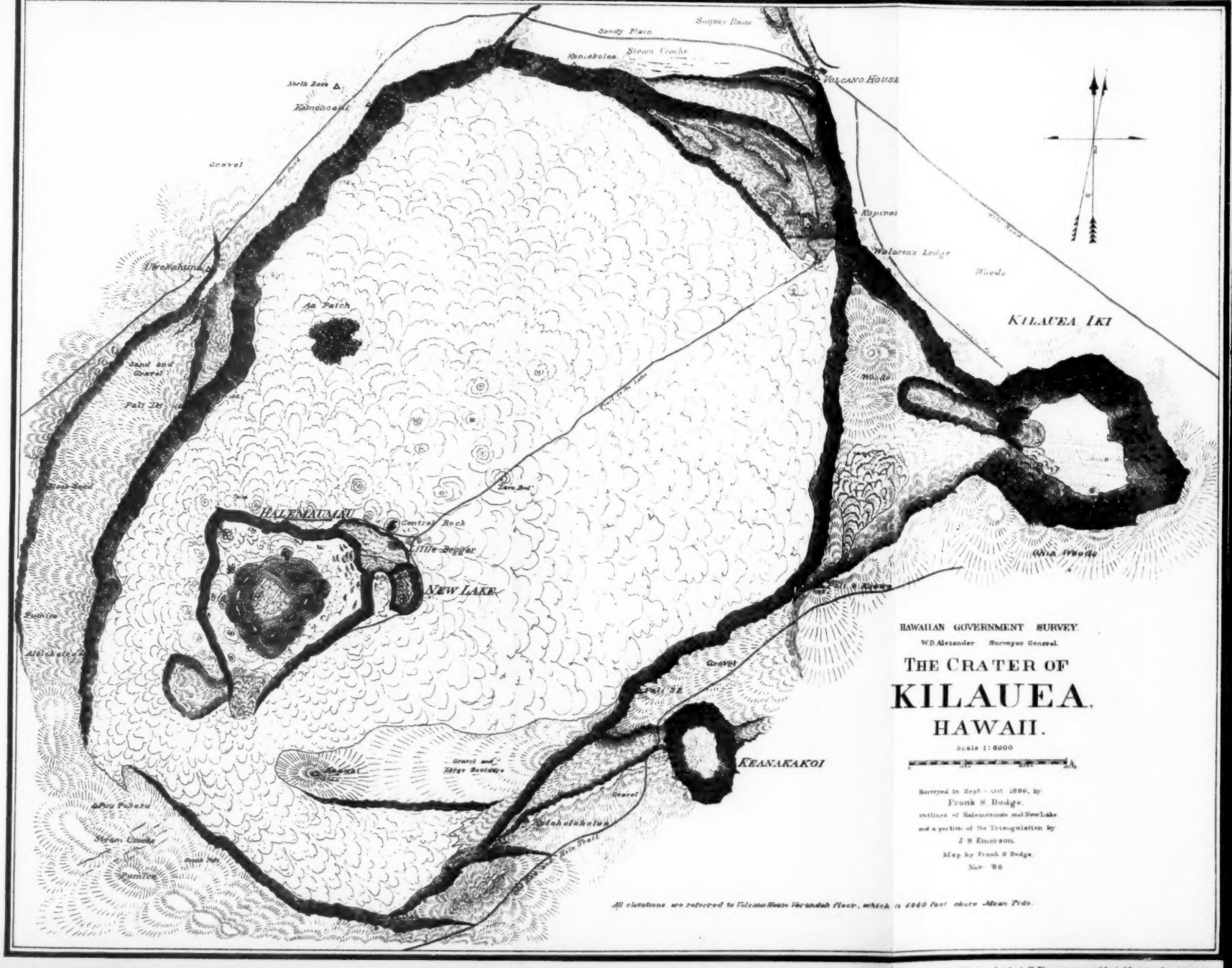
Scale 1: 20,000.

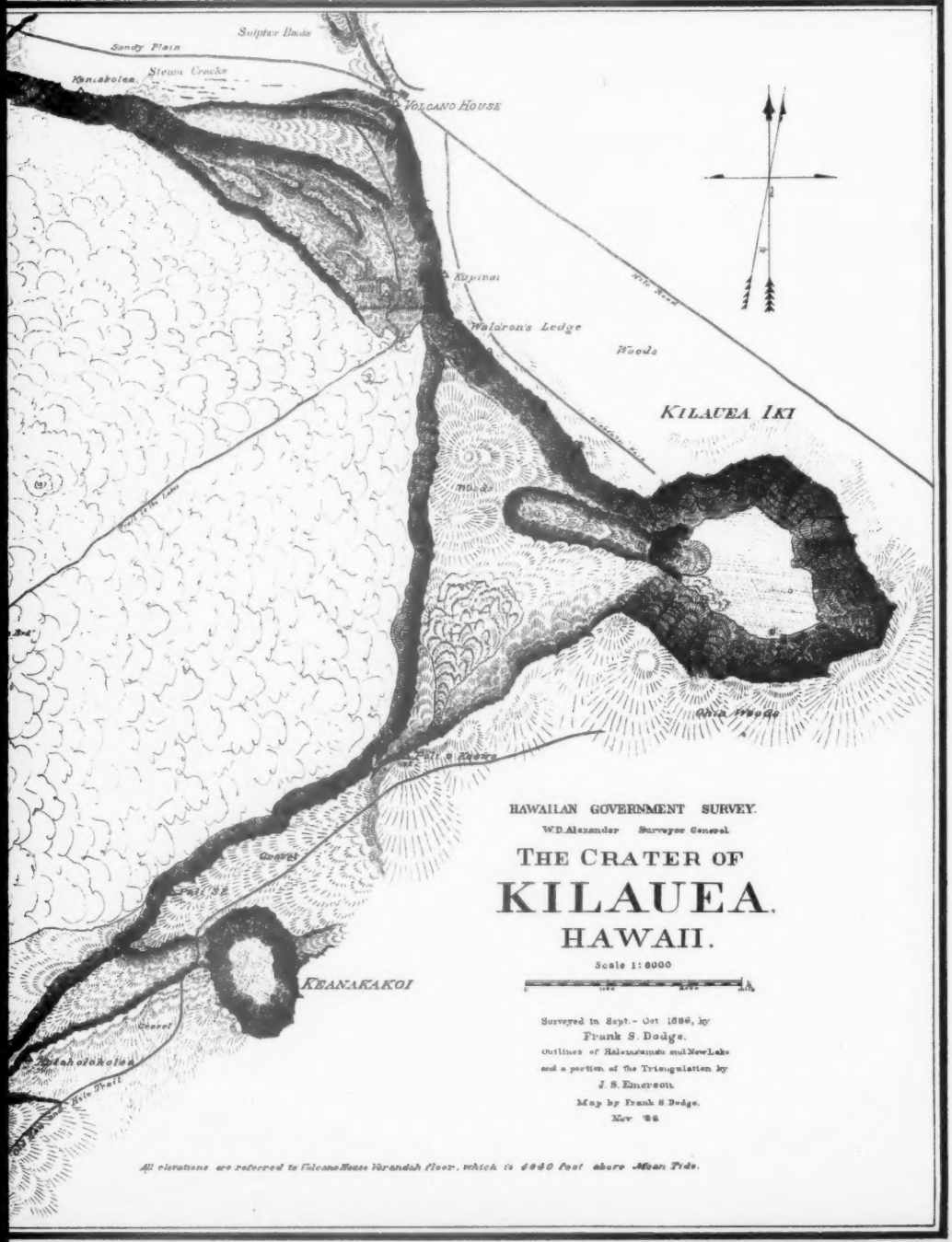
1000 2000 1 mile

Triangulation and Details of Sunken Portion are from Survey of April, 1886, by J. S. Emerson of the Hawaiian Government Survey

Outlines of Kilauea and the Small Craters from Wm T. Brigham's Survey of 1865.

Map by F. S. Dodge.
Aug '86.


Sandy Plain
Sulphur Banks
Kaneaholea
Steam Cracks
VOLCANO HOUSE
North Base
Kaneaholea
Gravel
Kapinai
Waiarena Ledge
Woods
KILAUEA IKI
Pali 1K
Sand and Gravel
Pali 2K
HALEMAUMAU
Central Rock
Little Beggar
NEW LAKE
Gravel
Pali 3E
KEANAKAKOI
Gravel and large Boulders
Kapaahu
Gravel
Pali 4E
Steam Cracks
Pumice
HAWAIIAN GOVERNMENT SURVEY.
W.D. Alexander Surveyor General.
THE CRATER OF
KILAUEA,
HAWAII.
Scale 1:6000
Surveyed in Sept - Oct 1886, by
Frank S Dodge.
outlines of Halemaumau and New Lake
and a portion of the Triangulation by
J S Emerson.
Map by Frank S Dodge.
Nov '86
All elevations are referred to Volcano House Verandah Floor, which is 4040 feet above Mean Tide.



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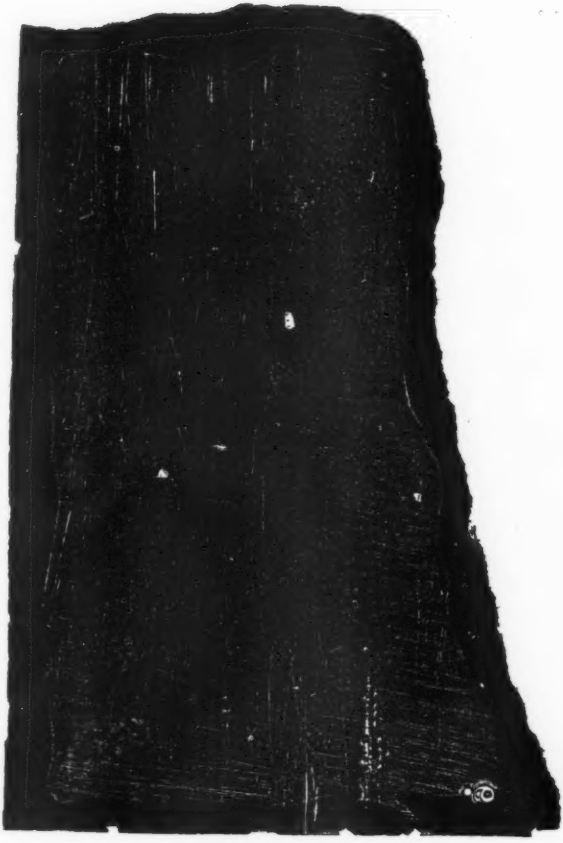
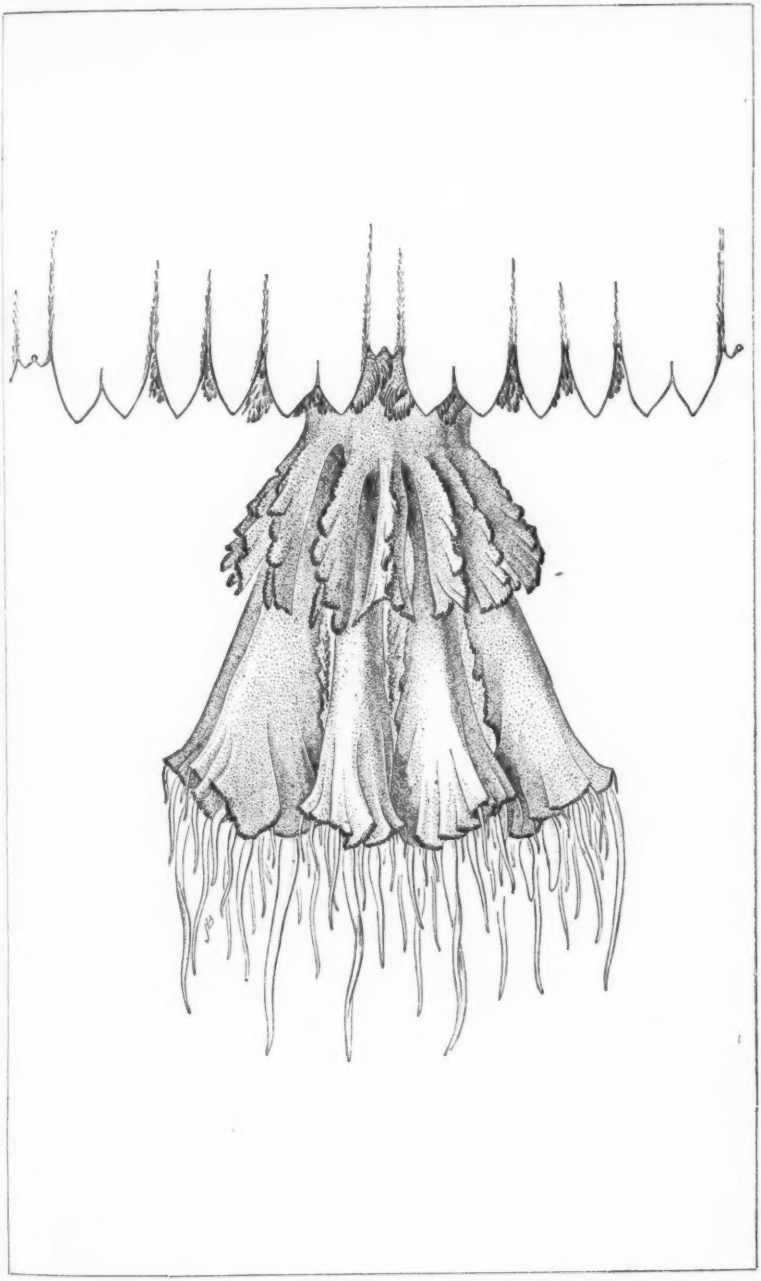


BUTCHER IRON.



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